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CONSTRUCTION FOUNDATION REPORT

NORTH BOUNDARY, RMA

AD A151284

ROCKY MOUNTAIN ARSENAL
Commerce City, Colorado

TEXT, DRAWINGS, PHOTOS

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MARCH 1984

US Army Corps of Engineers
Omaha District

DEPARTMENT OF THE ARMY
OMAHA DISTRICT CORPS OF ENGINEERS
6014 U.S. POST OFFICE AND COURTHOUSE
OMAHA, NEBRASKA 68102

REPLY TO
ATTENTION OF

MROED-GC 6 February 1985

SUBJECT: FINAL CONSTRUCTION FOUNDATION REPORT, North Boundary Expansion Containment System, Rocky Mountain Arsenal, Commerce City, CO

THRU: Commander, Missouri River Division
ATTN: MRDED

TO: Commander, USACE
ATTN: DAEN-MPE-D
Washington, D.C. 20315

1. In accordance with paragraph 10a of ER 1110-1-1801, Change 2, dated 1 April 1983, one copy of the subject report is inclosed.

2. Other copies will be distributed by MROAS-L in accordance with paragraphs 10b and 10c of ER 1110-1-1801.

FOR THE COMMANDER:

1 Incl
as

T. R. KELL, P.E.
Chief, Engineering Division

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This project was authorized by Directive No. 14, Design 80-MCA-Omaha District, dated 16 August 1979. This was an 8A set-aside Pilot Program, with a Small Business Administration negotiated contract.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Orgainic Contaminant	Dewater Wells
Bentonite Slurry Cutoff Barrier	Recharge Wells
Ground Water Hydrology	Treatment System
Permeability	Bedrock
Transmissivity	Excavation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The North Boundary Expansion Project is located at the north boundary of Rocky Mountain Arsenal, Commerce City, Colorado.

The system was constructed to contain and treat ground water which has been tainted by organic contaminants produced at the arsenal.

The system consists of: 1) A bentonite slurry cutoff barrier keyed into bedrock, 2) 48 dewater wells, 3) 26 recharge wells, 4) 39 monitor wells, and 5) a carbon absorption treatment plant.

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Foundation explorations include soil borings, bedrock sampling, geophysical logging, ground water hydrology testing and modeling, and bedrock and soil permeability.

The contract began in January 1981 and was essentially completed by October 1981. The contract number was DACA 45-81-C0054 and Ms. C. L. Smith was the geotechnical inspector.

ROCKY MOUNTAIN ARSENAL NORTH BOUNDARY EXPANSION CONTAINMENT SYSTEM CONSTRUCTION FOUNDATION REPORT

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CHAPTER 1. - INTRODUCTION

1.1 **LOCATION AND DESCRIPTION.** Rocky Mountain Arsenal (RMA) occupies 17,000 acres in Adams County, Colorado, 10 miles northeast of Denver's city center and directly north of Stapleton International Airport. The North Boundary Expansion Project (NBE) is located at the north boundary of RMA in Sections 23 and 24, T2S, R67W.

The project consists of:

(1) A bentonite slurry cutoff barrier at least 30 inches wide, keyed into impervious bedrock and tied into the pilot barrier. The expanded barrier extends 3,840 feet to the east and 1,400 feet to the southwest of the pilot barrier, as shown on Plate 5. Total length of the barrier including the pilot system is 6,740 feet, with an average depth of 33 feet.

(2) A total of 48 dewater wells upgradient of the barrier. Nineteen of these wells dewater permeable, potentially contaminated Denver Formation sandstone.

(3) Twenty-six recharge wells down gradient of the barrier.

(4) Thirty-nine monitor wells for monitoring ground-water levels and contamination. Five of the wells are cluster wells for sampling at several depths.

(5) A treatment plant for removal of organic contaminants by carbon absorption columns with an average flow capacity of 440 GPM.

1.2 **CONSTRUCTION AUTHORITY.** The North Boundary Containment/Treatment System project was authorized by Directive No. 14, Design 80-MCA-Omaha District, dated 16 August 1979. This was an 8A set-aside pilot program, with a Small Business Administration negotiated contract.

1.3 __PURPOSE OF REPORT__. This report was written in compliance with regulation ER 1110-1-1801, dated 14 January 1972, which requires as-built foundation reports for all major or unique construction projects. These reports are made to ensure the preservation for future use of information related to foundation conditions encountered during construction, methods used to adapt structures to these conditions, construction methods and procedures, contract modifications, design assumptions, deficiencies in plans and specifications, and possible causes of future problems. This information will also be part of the project Operation and Maintenance Manual and can be used for planning future explorations or instrumentation, designing future work or remedial measures, and providing case histories for use in design of comparable projects.

1.4 __PROJECT HISTORY__. RMA was established in 1942 to produce chemical warfare agents and incendiary munitions. Since 1946, portions of the RMA facilities have been leased to private industry for chemical manufacturing. Production of chemical warfare agents continued at RMA until 1957. In 1971, a demilitarization program was initiated at RMA to reduce stocks of obsolete chemical agents and munitions. Chemical production by private industry and the demilitarization program were still in operation during construction of the North Boundary Expansion.

1.4.1 During the production years (1942 to 1956), the industrial wastes generated at RMA by private lessee and Government operations were disposed of in unlined ponds. Basin "A," located in Section 36, was the most extensively used unlined pond. At the peak of production in 1955, the surface water area in Basin A reached approximately 300 acres. The use of the natural basin with no other provisions for waste containment allowed large amounts of contamination to percolate into the ground-water system. Unlined Basins "C," "D," "E," and "F" were also used during this time to contain overflow wastes from Basin "A."

1.4.2 The first indication of ground-water contamination outside of RMA came with a formal letter request for investigation from the Great Western Sugar Company to Brigadier General C. S. Shadle, RMA, dated 4 June 1954. A subsequent letter from the Great Western Sugar Company to the Chief of Engineering and Service Division, RMA, dated 18 June 1954, related more information concerning ground-water contamination. The letter described a correlation between crop damage and irrigation water from wells in farmland adjacent to RMA as early as 1951. Studies of the problem were initiated in November 1954 by the Corps of Engineers, Omaha District, in cooperation with the U.S. Geological Survey (USGS) at the request of the Commander, Rocky Mountain Arsenal. The COE Study, "Report on Ground-Water Contamination," September 1955, consisted of well-sample analyses for contamination and an electrical resistivity investigation to determine contaminant migration patterns. This study was supplemented by a USGS open file report by Petri and Smith, dated August 1956. These studies delineated general patterns of contaminant migration, and they recommended that a program be implemented to monitor the contaminated ground water.

Another study, conducted by the Ralph M. Parsons Company under contract with the Corps of Engineers, Omaha District, resulted in "The Final Report, Disposal of Chemical Wastes, Rocky Mountain Arsenal" on September 29, 1955. This report described studies of toxicity to plants, chemical constituents in irrigation wells near RMA, and provided recommendations for cost-effective further actions. The recommended actions included: (1) reducing the volume of contaminated water discharge from plants, (2) applying asphalt membrane seals in existing storage reservoirs, (3) investigating the possibility of reducing wastes into salable by-products, (4) neutralization of surplus acids into salts, and (5) solar evaporation of a portion of the waste liquids in the reservoirs to reduce liquid contents. It also recommended against the use of an injection well for disposal of liquid wastes.

Many of the recommendations were followed for reduction of waste volumes, and existing Basin "F" was lined with an impermeable sprayed asphalt

membrane covered with 1 foot of clay soil. Apparently no study of bentonite sealed reservoirs was conducted and no other waste reservoirs were lined to prevent continued leaching of contaminants into the ground-water aquifer. All process wastes since 1956 have been placed in Basin "F."

1.4.3 The U.S. Public Health Service, acting on claims of crop damage from the use of irrigation water on lands adjacent to RMA in 1958, performed a survey of damages. This study resulted in a report released in November 1959 which acknowledged the Government's responsibility for contamination of RMA-area ground water. This report provided impetus for containment and cleanup of contaminated ground water leaving RMA. The Omaha District was directed to perform a preliminary study of the ground-water problem at RMA by Office, Chief of Engineers (OCE), Directive No. 1, dated 18 March 1960. Results of this preliminary study were submitted to OCE in report form dated 11 May 1960.

1.4.4 By letter from OCE, dated 11 July 1960, the Omaha District was directed to proceed with completion of the final integrated study of the ground-water contamination at RMA, based on information available at that time. This study resulted in the comprehensive report "Program for Reclamation of Surface Aquifer," dated January 1961. This report accurately described the nature and extent of contamination, the nature of the phytotoxicants, and supplementary methods of waste disposal. It also provided several schemes for containment of the contamination. These schemes included the locations for barriers which were used when designing the North Boundary Expansion. Also recommended was a program for monitoring contamination and ground-water flows, and a program for further study of the nature of the contaminants and their effect on plants and animals.

1.4.5 By the summer of 1959, Basin "F" was dangerously close to capacity for two reasons: (1) the production of liquid wastes exceeded expectations, and (2) Basin "F," the only lined basin, had only two-thirds the capacity recommended in the Corps of Engineer's sponsored study due to

limited funds available to the Chemical Corps. The Chemical Corps, acting on the advice of their Industrial Advisory Council, decided upon a deep well for the underground injection of future wastes. Under contract to the Omaha District, U.S. Army Corps of Engineers, E.A. Polumbus, Jr., and Associates, Inc., produced the report, "Final Design Analysis, Pressure Injection Disposal Well, Rocky Mountain Arsenal," in July 1960.

The injection well was drilled in 1961 under the supervision of Omaha District to a depth of over 12,000 feet. The well penetrates pre-Cambrian gneiss. This well was unique in that it was by far the deepest injection well, and the injection area was in fractured crystalline rock as opposed to sedimentary rock commonly used for injecting wastes. Regular pressure injection of wastes from Basin "F" began 8 March 1962. On 23 November 1965, David M. Evans, a Denver geologist, publicly announced the results of a study conducted by him which alleged that injection of liquid wastes in the deep well at RMA was causing earthquakes in the Denver area. Mr. Evans based his allegation on the statistical correlation between volumes of waste injected into the well and the frequency of earthquake events. This correlation covered the period from March 1962 to October 1965, during which a total of 150 million gallons of waste were injected and a total of 710 earthquakes were recorded. Interest in a relationship between injection of fluids and earthquakes soon became widespread. Upon the advice of the Corps of Engineers, RMA reduced the rate of waste injection on 20 January 1966 and discontinued injection altogether on 20 February 1966. The investigation of the situation then expanded. The U.S. Geological Survey, University of Colorado, Colorado School of Mines, and the Corps of Engineers, Omaha District, cooperated on the investigation. The correlation between injection rates and earthquake frequency was confirmed, and in February 1969 injection of waste was permanently discontinued. Process wastes were again stored in Basin "F."

In 1974, contaminants that originated from RMA operations were detected in surface waters located to the north of RMA and in wells located near the city of Brighton. The State of Colorado Department of Health, following

Resource Conservation and Recovery Act guidelines, issued three Cease and Desist Orders against Shell Chemical Company (SCC) and RMA in April 1975. These Orders stated that:

(1) SCC and RMA immediately stop the off-post discharge of contaminants, both surface and subsurface.

(2) Take action to preclude future off-post discharge of contaminants.

(3) Provide written notice of compliance with item (1).

(4) Submit a proposed plan to meet the requirements of item (2).

(5) Develop and institute a surveillance plan to verify compliance with items (1) and (2).

As a result of these orders, a program was developed to satisfy the compliance criteria. The NBE is one of several projects designed to implement this program.

1.5 CONTRACTOR'S AND CONTRACT SUPERVISION. The contract was awarded to Alvarado Construction Company, 1260 Santa Fe Drive, Denver, Colorado. As prime contractor, Alvarado Construction built the treatment building addition, wet wells, sumps, well house assemblies, and performed site seeding. The contract began in January 1981, and site grading and clearing work began in February 1981. The slurry trench and well construction began in April 1981 and were completed in August 1981. The entire project was essentially completed by October 1981.

Several subcontractors were involved in the project construction and are listed on Table 1.

TABLE 1

CONTRACTOR	WORK PERFORMED
Engineered Construction International (ECI) 7400 S. Alton Ct. Englewood, CO	Site grading, service roads, slurry trench excavation and backfill.
Bechtold Drilling Co. 7790 W. 41st Ave. Wheatridge, CO	Dewater and recharge wells.
Franzen & Sons 5570 E. 56th Ave. Denver, CO	Water collection/distribution piping.
Tony's Painting 1990 W. Baltic Place Englewood, CO	Painting on site.
Sturgeon Electric 300 Vallejo Denver, CO	Electric high lines and poles.
Western Testing 775 Sheridan Blvd. Denver, CO	Concrete, gradation, and backfill testing.
Chen & Associates 3405 N. El Paso Denver, CO	Additional testing, including barrier permeability.
Western Blasting Contractors, Inc. 3155 N. Commerce Ct. P.O. Box 1107 Castle Rock, CO	Blasting in trench excavation.

The treatment plant was constructed under the direction of RMA by Westvaco.

1.6 **KEY RESIDENT AND DESIGN STAFF**. Design of the system was developed by Black & Veatch Consulting Engineers, Kansas City, Missouri, with Earth Science Associates, Ft. Collins, Colorado, as the hydrologic investigators. Omaha District, under District Engineer Colonel V. D. Stipo, provided engineering review and construction inspection of the project. Key design personnel in Engineering Division include G. Williams, Military Branch; L. Tate,

Design Branch; M. Taylor, M. Kelley, O. Spring, E. Kovanic, and J. Zeltinger, Foundations and Materials Branch. C. Smith, Foundations and Materials Branch, provided field inspection and geotechnical expertise during the well and slurry trench construction. Construction Division personnel include W. Evans and R. Caraveaux, Supervision and Inspection Branch. The Rocky Mountain Area Office, under Colonel P. Weinert, Area Engineer, was responsible for project construction. Key Rocky Mountain Area personnel include K. Thonen, Resident Engineer, and R. McRae, Project Engineer. Technical expertise and review during design and construction was provided by J. Albritton, Missouri River Division geologist.

Design of the treatment system was retained by RMA. The system was designed by Rubel-Hager, Inc., with technical review by RMA. Key RMA personnel include Dr. W. McNiel, C. Loven, and E. Berry.

Review of plans and specifications was performed by the U.S. Army Toxic and Hazardous Armament Materials Agency (USATHAMA), U.S. Army Materiel Development and Readiness Command (DARCOM), and ARRCOM. Initial studies and the Environmental Impact Statement were accomplished by USATHAMA.

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CHAPTER 2. - FOUNDATION EXPLORATION AND STUDIES

2.1 Many organizations were involved in the design studies for this project. Much of the information came from the numerous piezometers, borings, monitor wells, and chemical analyses performed by RMA personnel. The pilot containment and treatment system, built in 1978, provided basic design information for the NBE project. Other government agencies involved with investigations for this project include the Omaha District Corps of Engineers, Waterways Experiment Station, U. S. Army Toxic and Hazardous Armament Materials Agency, U. S. Geological Survey, and the Colorado Department of Health.

2.2 PRE-CONSTRUCTION INVESTIGATIONS. A number of pump tests and interference tests were performed prior to 1961 to determine aquifer and ground-water characteristics. From the test data obtained, the hydraulic conductivity factor was 1,500 ft/day; the factor for the average storativity was 20%. Average porosity was computed as 35%. The distance from Reservoir A (Plate 85) to the South Platte River showed a 20 ft/mi. hydraulic gradient, with the average velocity of movement 16 ft/day.

2.2.1 A comprehensive study of ground-water contamination was completed by the Omaha District Corps of Engineers in January 1961. This report, titled "Program for Reclamation of Surface Aquifer, Rocky Mountain Arsenal," was the first report to identify major contaminant sources and contaminated ground-water plumes, as well as provide containment/collection system schemes and locations for the proposed systems. All following investigations generally confirmed the hydrologic information and preferred containment system locations as submitted in the 1961 report. The information derived from this report is shown on Plates 1 through 4. The disposal methods for contaminated water are not included in this report.

2.2.1.1 In May 1976, the Decontamination Systems Technical Working Group directed the Waterways Experiment Station (WES) to develop

interim design criteria for a small scale containment/treatment system for the Arsenal, which included a pilot slurry wall. Previous studies by the USGS had used hydrologic models which indicated contaminant flow problems at the north boundary. The WES program included a series of well pumping tests at the Arsenal to establish aquifer characteristics and soil sampling. Soil samples were provided by WES to D'Appolonia, Consulting Engineers, Inc.

2.2.1.2 In addition, the WES study included a water quality monitoring program, determination of sampling methods, and the determination of ground-water and contaminant flow. It was found that, although ground water in the area was hydraulically a single body of water, it could best be represented by considering the flow as two separate bodies of water which converged at the north boundary. One of the flows moves under Basin "F" where contaminants are leeched from the basin and flow northward. Ground water levels force the contaminants to follow an old channel that trends northeast out of the Basin "F" area. As the contaminants migrate along the channel to a point just east of the line between Sections 23 and 24, they are pushed to the north by the inflow of uncontaminated water from the southeast. It was found that ground-water flow velocities ranged between 0.3 cm/day to 100 cm/day and in the area of major contamination were about 12 cm/day.

2.2.1.3 The sampling and testing program by WES also provided soil parameters on moisture content, unit weight, Atterberg limits, grain size distribution, and shear strength. Soil borings were made by RMA and testing done by WES. Multistage and single stage aquifer pump tests were performed to determine transmissivities and specific capacities. Pump tests indicated that the aquifer was under semiconfined conditions. The WES studies also recommended the pilot slurry trench which was installed by RMA.

2.2.1.4 D'Appolonia, Consulting Engineers, Inc., ran permeability, viscosity, and density tests on soil samples that were provided by WES. Soil properties were evaluated for permeability and for suitability

for mixing with bentonite slurry for backfill. Two types of soils were tested for permeability tests; one was a fine to coarse sand (Soil A) and the other a sandy clay (Soil B) with 67 percent passing the No. 200 sieve. Soil A classified as an SM and Soil B was a CL. Bentonite used for the slurry mix was premium gel and the permeating fluid consisted of a 50-percent Basin "F" fluid diluted with distilled water. The soil bentonite samples were mixed to obtain a 40-second marsh cone value. Test specimens were allowed to consolidate in triaxial cells under 1 kg/cm^2 pressure, and permeated with distilled water for several days until the samples were saturated and de-aired. The 50-percent diluted Basin "F" fluid was then applied to the sample as the permeating fluid. Permeability values were computed by using Darcy's law where $Q = KiA$. Table 2-1 gives permeability test results and Table 2-2 is a description of the test samples. Figures 2-1 and 2-2 are gradation curves for soil types A and B.

Table 2-1

Sample No.	Time (Days)	Average Permeability (Cm/Sec.)
1	97-100	1.5×10^{-7}
2	92-100	8.0×10^{-8}
3	92-100	2.2×10^{-8}
4	92-100	1.3×10^{-8}
5	89-97	9.7×10^{-8}
6	88-96	1.1×10^{-7}
7	92-100	2.1×10^{-7}
8	92-100	5.1×10^{-8}
9	92-100	1.6×10^{-8}
10	92-100	2.0×10^{8}
11	89-97	1.1×10^{-7}
12	89-97	1.9×10^{-7}

TABLE 2-2

DESCRIPTION OF TEST SAMPLES

Sample No.	Description
1	Cement-bentonite
2	Soil A + bentonite + 10% Soil B.
3	Soil A + bentonite + 25% Soil B.
4	Soil A + bentonite + 40% Soil B.
5	Soil A mixed with 10% of a 1 to 15 dilution of the Basin F fluid which is then air dried. Subsequently, 10% Soil B and 1% dry bentonite is mixed into the sample and then slurry is added to obtain the required slump.
6	Soil A mixed with 10% of a 1 to 15 dilution of the Basin F fluid which is then air dried. Subsequently, 1% dry bentonite is mixed into the sample and then slurry is added to obtain the required slump.
7	Cement-bentonite with Marasperse C-21 (an additive).
8	Soil A + bentonite + 10% soil B.
9	Soil A + bentonite +25% Soil B.
10	Soil A + bentonite + 40% Soil B.
11	Soil A mixed with 10% of a 1 to 15 dilution of the Basin F fluid which is then air dried. Subsequently, 10% Soil B and 1% dry bentonite is mixed into the sample and then slurry is added to obtain the required slump.
12	Soil A + bentonite + 10% Soil B.

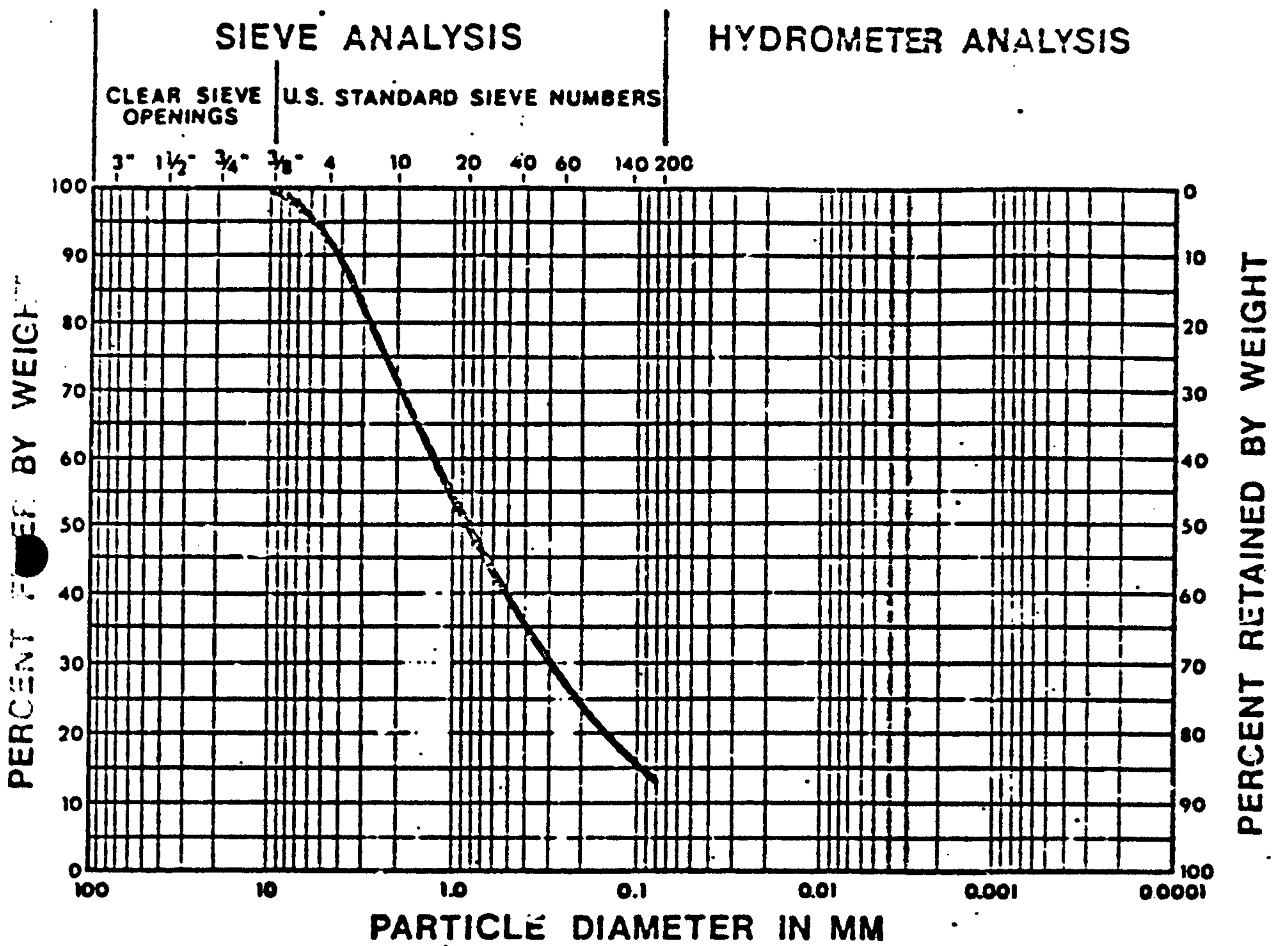


FIGURE 2-1

GRAIN SIZE ANALYSIS
SOIL A

PREPARED FOR

U.S. ARMY
WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

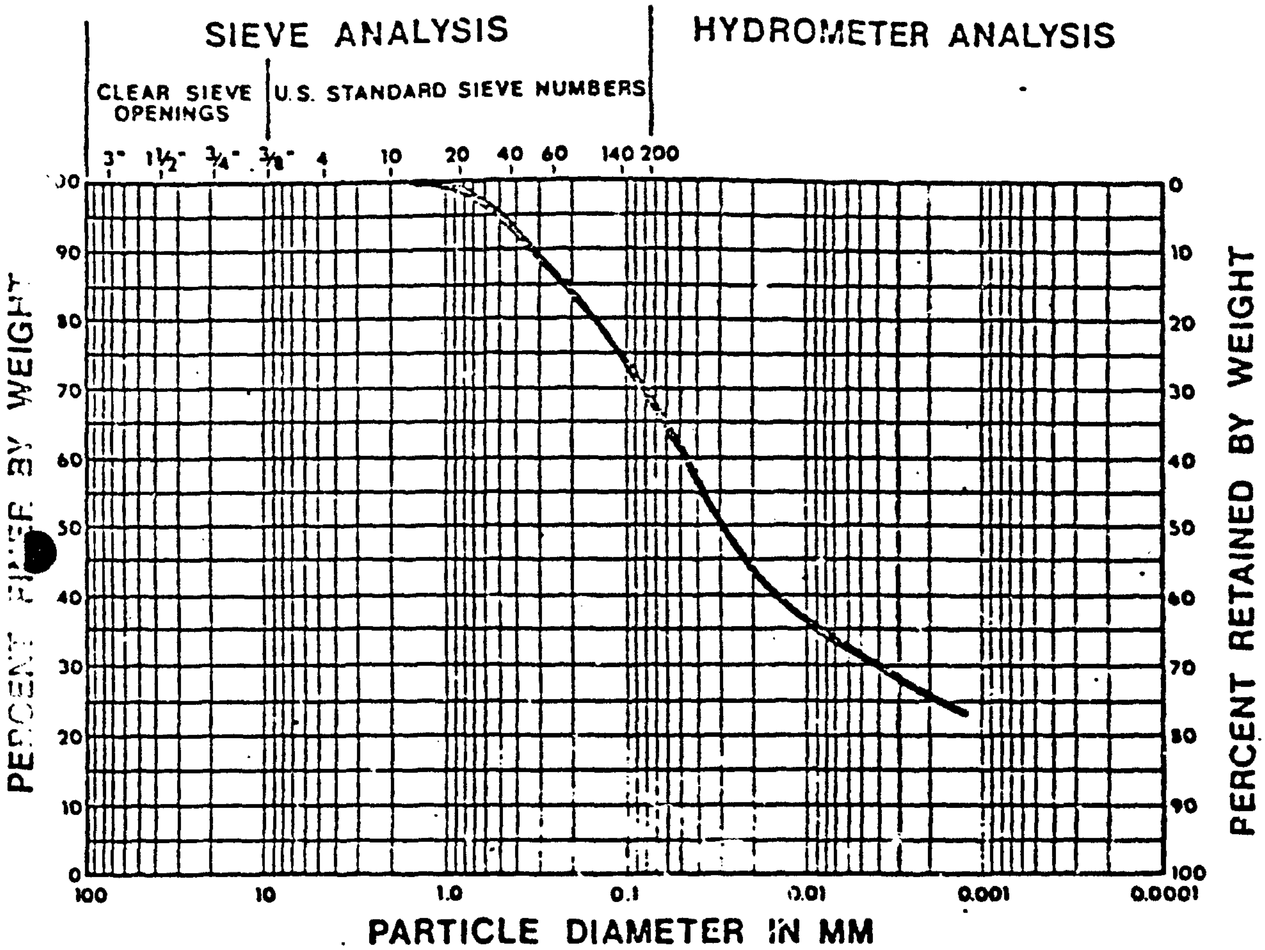


FIGURE 2-2

GRAIN SIZE ANALYSIS
SOIL B

PREPARED FOR

U.S. ARMY
WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

TABLE 2-3

TEST RESULTS

SPECIFIC GRAVITY AND VISCOSITY
MODEL BENTONITE SLURRY TRENCH

Time (Days)	Mud Balance Specific Gravity	Marsh Cone (Seconds)	Remarks
Initial	1.02	40	Before slurry was placed in model
1	1.02	43	
2	1.02	43	
3	1.02	43	
4	1.02	45	
5	1.02	43	
6	1.02	44	
7	1.02	44	Seepage of slurry into soil
14	1.03	59	Level of bentonite dropped ~1"
21	1.03	52	Level of bentonite dropped another ~3/4"
28	1.03	68	
59	1.04	90	
90	1.04	104	Level of bentonite dropped total of ~3 1/2"
101	1.05	52	Bentonite slurry completely mixed
101	1.03	41	Data after 10% diluted Basin F fluid added to slurry
102	1.03	41	
103	1.035	38	
104	1.03	40	
105	1.03	41	
106	1.03	40	
107	1.04	41	
108	1.03	41	

D'Appolonia also constructed a model bentonite slurry trench to test viscosity and density of the bentonite slurry. Soil type A, Premium Gel Bentonite, and Basin "F" fluid (diluted 15:1 with distilled water) was used in the model. Test results of the slurry mix are given on Table 2-3.

2.2.2 The issuance of the Cease and Desist Orders by the Colorado Department of Health resulted in the resumption of studies for containing and treating contaminated ground water at RMA. Several schemes were studied to determine the best method for treatment of RMA waste, resulting in the selection of a carbon absorption system in conjunction with a bentonite barrier, dewater wells, and recharge wells, to be placed at the north boundary as shown on Plate 5. The pilot containment system was to be studied for further application of this procedure, if effective. The pilot system, built in 1978, proved to be effective in treating the contaminated ground water to the required standards. It was determined that the pilot system was to be expanded to treat all contaminated water at the north boundary to the standards shown in Table 2-4.

TABLE 2-4

PARAMETER	APPLICABLE LIMITS IN DRINKING WATER	REFERENCE
Aldrin	Hold exposure to a minimum	"Quality Criteria for Water" EPA, 1976
DBCP	0.0002 mg/l	State of Colorado limit per letter to Commander, RMA (Appendix B)
DCPD	1.3 mg/l (Toxicity) 0.024 mg/l (odor)	These guidelines are recommended by the US Army Medical Bioengineering Research & Development Lab (26 Aug 76) and are based on Toxicology studies conducted by the Army. The National Academy of Sciences Committee on Military Environmental Research has reviewed the procedures and results of the Toxicology studies and concurred in the drinking water levels (1 Feb 77). The State of Colorado has concurred with the 0.5 mg/l level for DIMP but has requested the Army to meet a lower limit of 0.024 mg/l for DCPD based on an odor threshold value.
DIMP	0.5 mg/l	
Dieldrin	Hold exposure to a minimum	"Quality Criteria for Water" EPA 1976
Endrin	0.0002 mg/l	EPA National Interim Primary Drinking Water Regulation
Fluoride	2.4 mg/l	State of Colorado limit for quality of reinjection water per letters to Commander, RMA (Appendix B).
	1.8 mg/l	EPA National Interim Primary Drinking Water Regulation, 1975 (Temperature dependent value)

p - Chlorophenylmethylsulfide) State of Colorado interim standard
p - Chlorophenylmethylsulfoxide) - sum of three not to exceed 100 mg/l
p - Chlorophenylmethylsulfone)

The pilot facility was to be expanded by extending the cutoff wall 3,840 feet east and 1,400 feet to the west. Additional dewatering wells were provided to intercept all of the flow in the alluvial aquifer and suspected or possible contaminated flows in the upper Denver Sands. Treatment capacity was to be expanded and additional recharge wells provided to reinject treated water to essentially restore the natural flow system. Other design considerations were as follows:

(1) The concept adapted by RMA and COE, based on criteria received from RMA, required detailed quantification of flow and contaminant fluxes for each segment of the alluvial aquifer, so that three zones of flow could be intercepted and manifolded to separate treatment modules. Dewatering wells were to be distributed across the entire flow system to minimize dispersion of contaminants by gradient changes.

(2) Alluvial aquifer dewatering wells upgradient from the cutoff wall were to selectively intercept three zones of contamination by manifolding groups of wells across the barrier, thus permitting separate treatment of these waters.

(3) The dewatering rate was as close to the natural flow rate as possible, and to slightly exceed the natural flow rate, at least during initial years of operation, to prevent excessive rise in water levels and flooding over the cutoff wall in low lying areas.

(4) The cutoff wall extensions were to be constructed by excavating bentonite slurry trenches backfilled with select material mixed with bentonite slurry to form a hydraulic barrier through the alluvium and into the Denver Formation. The cutoff wall extensions were to penetrate shallow Denver Formation sandstone deposits having hydraulic connection with the alluvial aquifer at the barrier. Additionally, the cutoff wall was to penetrate fractured shales of the Denver Formation to provide protection against fracture flow through the underlying shales.

(5) The existing slurry cutoff wall was to be left undisturbed. There is a shallow and rather extensive Denver Formation sandstone layer beneath the existing barrier that contains low levels of contaminants. Flow through this sand layer was to be intercepted by Denver Formation sandstone dewatering wells, although the flow through this sand layer is only about 0.75 gpm under existing gradients and available analyses indicate this water meets standards for DIMP, DCPD, DBCP and Fluorides. Concern had been expressed about flow through fractures in shales between the base of the existing barrier and the underlying Denver Formation sandstones. Computations indicate this flow, if not intercepted by the Denver Formation sandstone dewatering wells, would amount to only 0.06 gpm. Even if Denver Formation sandstone dewatering wells were not constructed, flow beneath the existing cutoff wall would be only 0.81 gpm under estimated gradients. Therefore, it was Earth Science Associates' (ESA's) recommendation that the existing pilot cutoff wall be left undistrubed and that Denver Formation sandstone dewatering wells be used to monitor the quality of flow and dewater the shallow Denver Formation sandstones on an as needed basis.

(6) Denver Formation sandstone dewatering wells were to be constructed to intercept suspected or possible contaminated flows beneath the cutoff wall in the Denver Formation sandstones to depths of up to 105 feet. A pumping depression was to be developed to contain and collect these flows.

(7) Recharge wells were to be constructed downgradient from the cutoff wall to reinject treated water. Recharge was to be distributed across the flow system so that natural flows were maintained within the constraints of barrier operation. It was estimated that about 110 percent of the natural alluvial flow would be recharged because of the overpumping requirement for operation of dewatering wells, at least during the initial years of operation.

2.2.3 Design Methodology. Existing data including reports and field logs were collected and analyzed. Data stored on magnetic tapes were screened

and coded for retrieval in a usable form. Field data including logs and pump test data were used to check computer outputs and data interpretations. Preliminary geologic sections were constructed, water levels and chemical data were contoured, and time concentration graphs were constructed. Existing pump test data were reinterpreted for hydraulic parameters.

2.2.3.1 A field exploration program was planned and performed by ESA to provide more detailed geologic, geohydrologic, and chemical data. Field work for the project commenced January 3, 1980 and was completed March 23, 1980. A total of 48 holes were drilled (Numbers 1000 through 1047 on Plates 19-40) to depths ranging from 20.5 feet to 80.0 feet. Thirty holes were located along or adjacent to the proposed barrier alinement; 18 holes were located in the vicinity of the recharge and discharge well alinement. A total of 19 of the holes were completed as wells. Gradation tests were run on 62 samples within the alluvium and unconfined compressive strength tests were run on rock cores. Between one and four drill rigs were operating on the site, five to seven days per week. Drilling companies used for the project were Custom Auger Drilling and Virginia Drilling, both of Denver, Colorado.

2.2.3.2 The 30 exploration holes drilled along or adjacent to the proposed barrier alinement included Numbers 1000 through 1029. East of the existing pilot barrier, depths ranged from 65.5 feet to 75.2 feet and 49.9 feet to 80.8 feet along and to the west of the existing pilot barrier. These holes were drilled utilizing the following procedure: A 6-inch flight auger was used to auger through the alluvium and standard split-spoon samples were driven approximately every 5 feet. Five and one-half inch, temporary steel casing was then placed within the alluvium and partially into the weathered Denver Formation. The Denver Formation was cored continuously with PQ-3 wireline coring equipment (see Plates 19-40). Diamond bits and three different types of carbide bits were used. The holes were geophysically logged by Colorado Well Logging of Golden, Colorado. Spontaneous potential,

resitivity, gamma, gamma-gamma, neutron, and caliper logs were run on each hole. These logs are shown on Plates 47 through 76. Twenty-five holes were backfilled with a 50-50 slurry mixture of bentonite and cement. Five holes (Nos. 1024, 1021, 1019, 1018, and 1017) were completed with isolated well screen utilizing a bentonite seal at the bottom, a filter pack of pea gravel around the screened interval, a bentonite seal above the screened interval, and a 50-50 slurry mixture of bentonite and cement to the surface. The temporary steel casing was removed from all of the holes.

2.2.3.3 The 18 holes located in the vicinity of the recharge/-discharge well alinement (Nos. 1030 through 1047) were drilled using a 6-inch flight or hollow stem auger, or 5-inch, 8-inch, or 11-3/4-inch tricone bits. Depths of the holes ranged from 20.5 feet to 67.0 feet. Standard split-spoon samples were driven approximately every 5 feet in Holes 1030, 1031, 1033, 1034, 1035, 1037, 1038, 1039, and 1040. Four holes, 1032, 1036 (alluvium), 1041, and 1045 (Denver Formation sandstone), were completed as wells. Steel casing and screen 6 inches in diameter was installed in Wells 1031 and 1036, and a gravel envelope was used around the screen. Wells 1041 and 1045 in the Denver Formation sandstone were completed using 4-inch slotted PVC and a thin gravel envelope. A conductor casing was cemented into the alluvium above the screened zones. Pump tests were run on these holes for up to five days. Nine holes, 1030, 1031, 1033, 1034, 1042, 1043, 1044, 1046, and 1047, were completed as observation wells using 2-inch slotted PVC pipe. The five holes not completed as wells, 1035, 1037, 1038, 1039, and 1040, were backfilled with a 50-50 slurry mix of bentonite and cement.

2.2.3.4 Pump tests of wells in borings 1032, 1036, 1041, and 1045, in addition to aquifer tests performed by Waterways Experiment Station (see Tables 2-5, 2-5a, 2-5b, and 2-6), were used to design dewatering wells. These wells are designed to develop a pumping trough to intercept possible contaminated sands. Distance drawdown calculations were used to design well spacing and pumping rates. Because of the irregular configuration and location of sand lenses, these calculations are only approximate and adjustments in pumping rates may be required.

2.2.3.5 The slurry cutoff wall extensions were designed as geologic and soils data became available. Specifications were prepared based on existing data, and backfill requirements were evaluated after gradation tests of soils were completed. Excavation requirements were incorporated into design drawings as they became available.

2.2.3.6 Construction materials for pumps, pipe, valves, etc. used in the dewatering system are based on results of the Engineering and Construction Materials Compatibility Study by the U.S. Army Engineer Waterways Experiment Station. Using agency experience confirmed that PVC is the most suitable material.

2.2.3.7 Monitoring wells for the alluvial aquifer and the Denver Formation sandstones were located as shown on Plate 80. Existing wells were incorporated as much as possible into the monitoring system.

2.2.4 Simulation of the geohydrologic system in the vicinity of the NBE was accomplished by construction of a digital model as proposed by Trescott, Pinder and Larson (USGS, 1976). The design concept of selective interception of contaminant flows required a rigorous analysis of flows across the boundary that could best be simulated and analyzed with finite-difference techniques. This model enabled simulation of flow segments across the boundary within the limits of precision of the hydraulic conductivity data and the water level contours used for calibration of the model. The model was then used to distribute dewatering and recharge rates for wells and simulate the hydraulic effects on the alluvial flow system.

2.2.4.1 Contaminant fluxes for each control constituent were estimated for each dewatering well based on hydraulic effects simulated by the model and evaluation of contaminant plumes. Also, upper limit fluxes were estimated for each dewatering well based on the highest concentrations upgradient from the barrier system. Dispersion and sorptive effects were

ignored in these estimates, resulting in conservative values, especially for upper limit estimates. This finite-difference model simulated the aquifer's response to stresses in two dimensions and enabled representation of complex boundary conditions and system heterogeneities by approximating the partial differential equation governing ground water flow with finite differences for the derivatives at numerous distinct nodes representing the aquifer. The resulting system of algebraic equations (one for each node in the system) was solved using a highly efficient technique known as the "strongly implicit procedure". For the North Boundary model, the finite-difference grid contains 2,958 cells (29 rows by 102 columns) as shown on Figure 2-3. Each cell has a node at its center. The cells are 100 feet by 100 feet near the slurry cutoff wall and are up to 100 feet by 500 feet to the north and to the south. Given a distinct system geometry, aquifer characteristics, boundary conditions, and initial water levels, the model solved for the average hydraulic heads at each node.

2.2.4.2 Boundary conditions modeled consist of no-flow boundaries and constant head boundaries. No-flow boundaries are represented by specifying a permeability of zero at the nodes outside the boundary. The harmonic mean of the permeability at the cell boundary is zero, and as a result there is no flow across the boundary. A boundary condition of this type was used where alluvium is absent or unsaturated and along the small basin to the southeast. The bedrock high areas are believed to be much less permeable than the alluvial aquifer, and their treatment as no-flow areas is therefore justified. Constant head boundaries were assumed where no physical boundaries existed. Along these boundaries, heads were fixed at "steady state" values which were based upon best available water level data. These fixed head boundaries will not influence model results when hydraulic stresses are located far from these boundaries and the simulation period is short.

2.2.4.3 The finite-difference model assumes the aquifer may be represented as a two dimensional, isotropic, homogeneous unconfined system with a nonleaky underlying layer. In other words, it was assumed that the

FINITE DIFFERENCE GRID

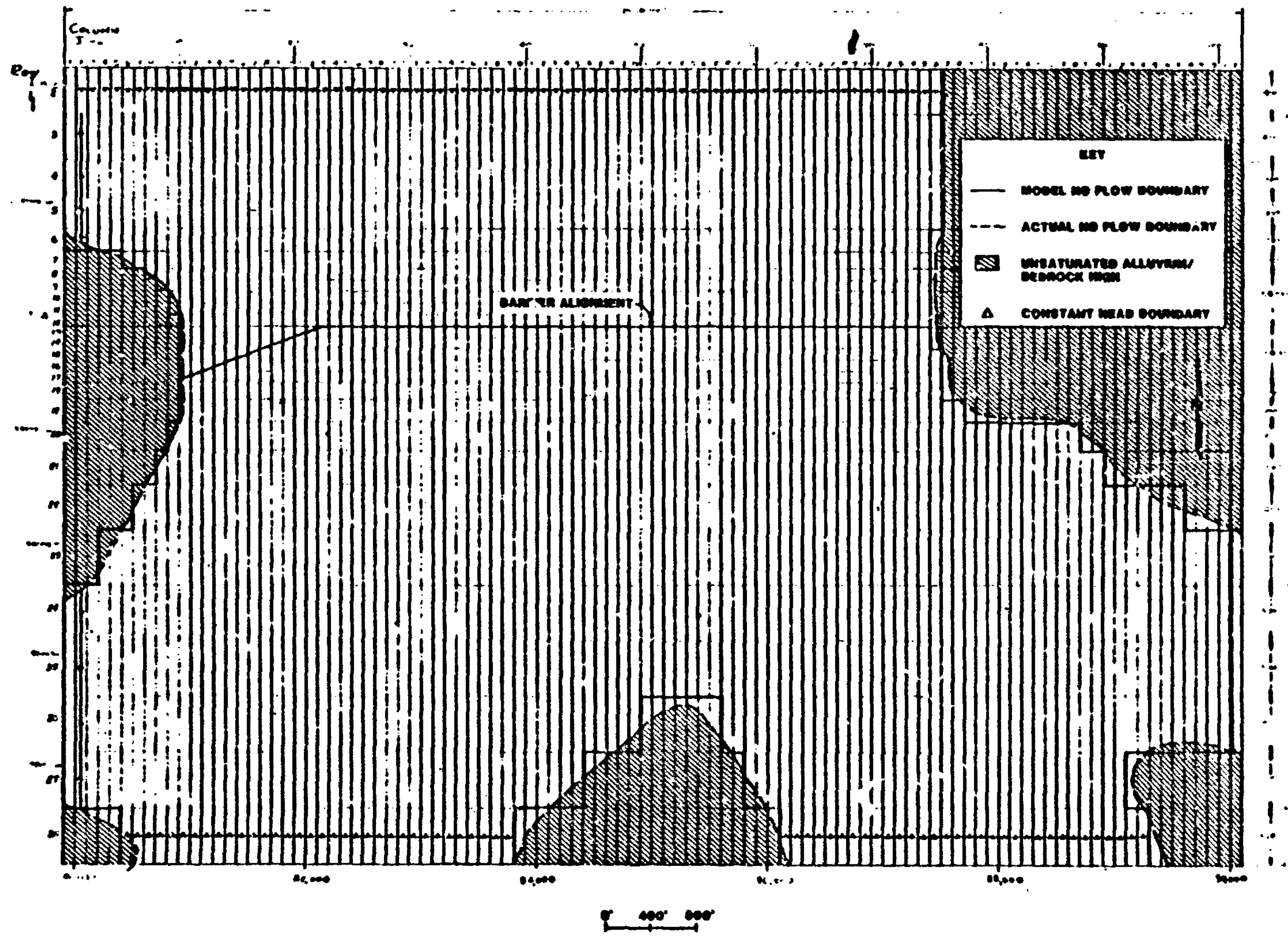


FIGURE 2-3

Denver Formation is impermeable. This is a valid assumption, for modeling purposes because of the extremely low permeability of the Denver Formation. Within the model area, recharge from precipitation is negligible and evapotranspiration is assumed to be negligible. There are evapotranspiration losses in the bog area mainly downgradient from the barrier, but the losses are estimated to be less than 5 percent of the alluvial aquifer flow.

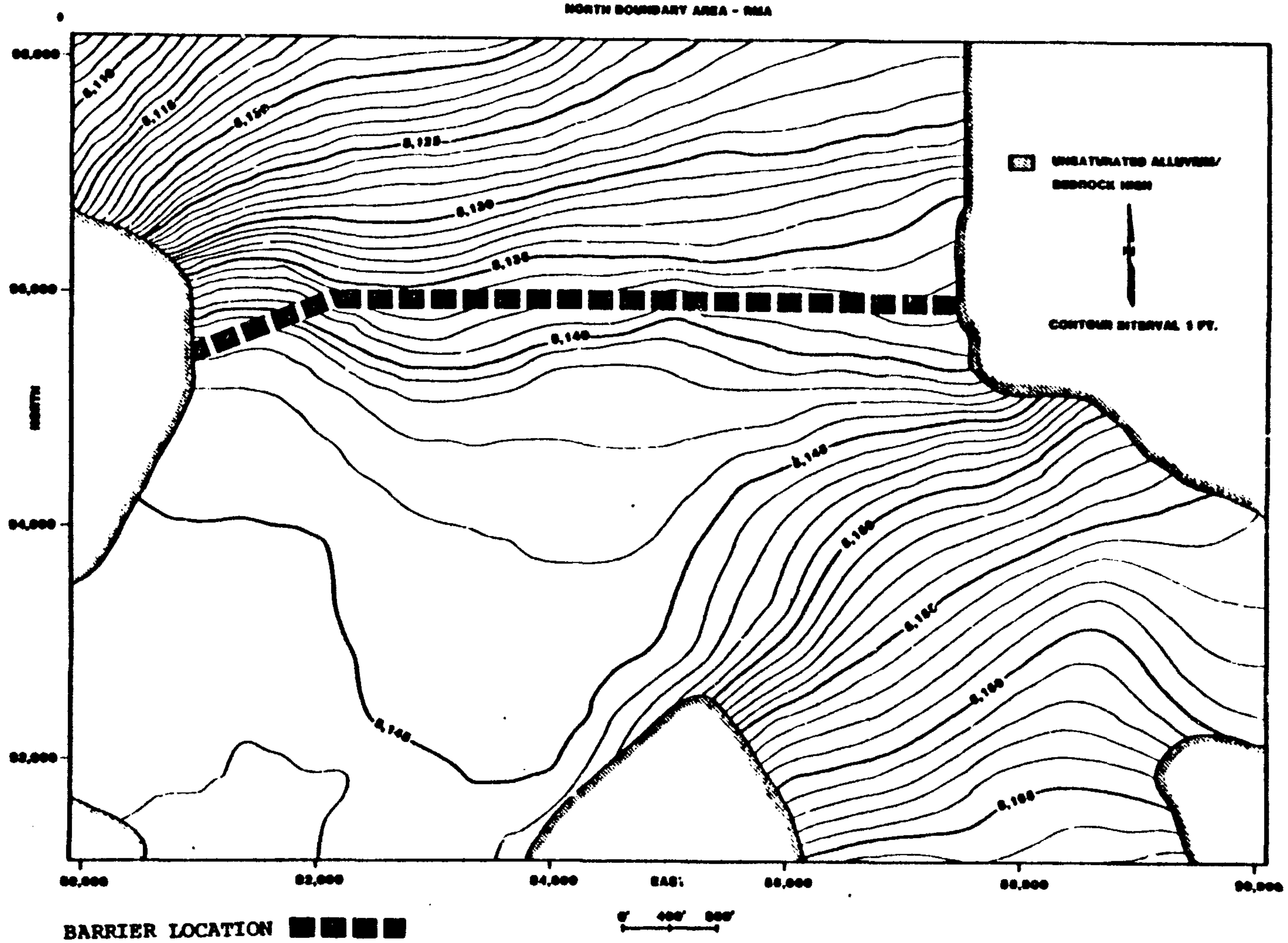
2.2.4.4 Computation of in-well hydraulic heads at the pumping and recharge wells was accomplished by employing a form of the Thiem equation. This was necessary for extrapolating from the average hydraulic head for each cell to the head at the effective well radius (8 inches for pumping wells and 1 foot for recharge wells.) This approximation was based on the following assumptions: (1) flow takes place within a square well block (grid cell in three dimensions) and can be described by a steady state equation with no external sources; (2) the aquifer is isotropic and homogeneous within the well block; (3) only one well is in the well block and it is fully penetrating; (4) flow is laminar; and (5) well loss is negligible. For design purposes, model produced drawdowns were increased by 10 percent to account for well friction losses. Extremely low friction losses were anticipated because of the large open area of screens and low pumping rates.

2.2.4.5 Calibration of the finite-difference model consisted of distributing permeabilities throughout the nodal system so that model simulated water levels matched observed water levels that were reasonably near a steady state. This was necessary because inflows and outflows to the system are unknown, but were assumed to be equal because recharge and evapotranspiration within the modeled area are negligible. The finite-difference model requires that an average hydraulic conductivity, specific yield, bedrock elevation, and water level be specified at each node. The saturated thickness of the alluvial aquifer was determined by the elevation difference between water level contours shown on Figure 2-4 and bedrock contours shown on Figure 2-5. Saturated thickness is shown on Figure 2-6. Water level contours used are based on spring 1979 water level measurements.

GROUNDWATER ELEVATIONS

SPRING 1979

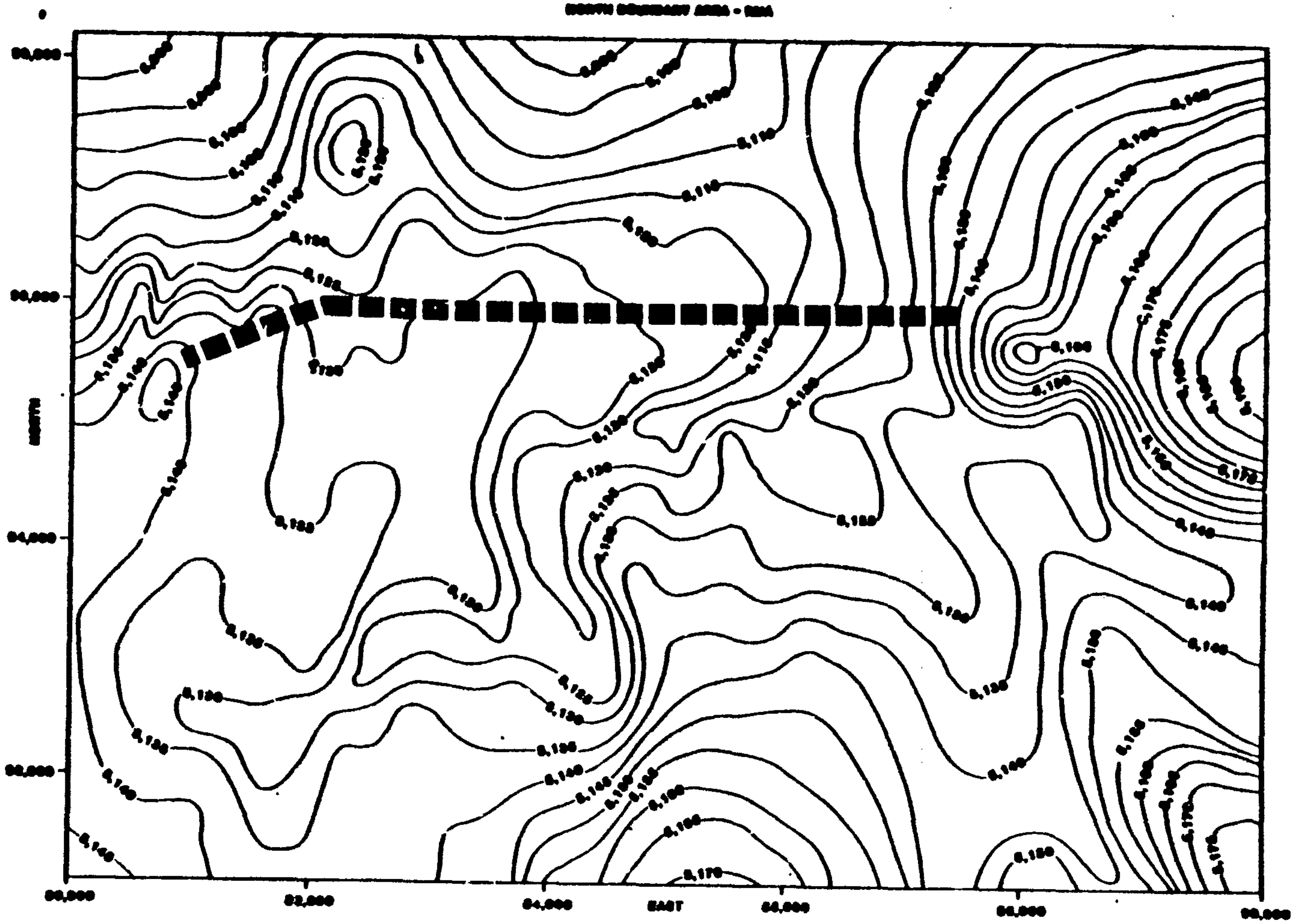
NORTH BOUNDARY AREA - RMA



BARRIER LOCATION

FIGURE 2-4

BEDROCK CONTOUR MAP



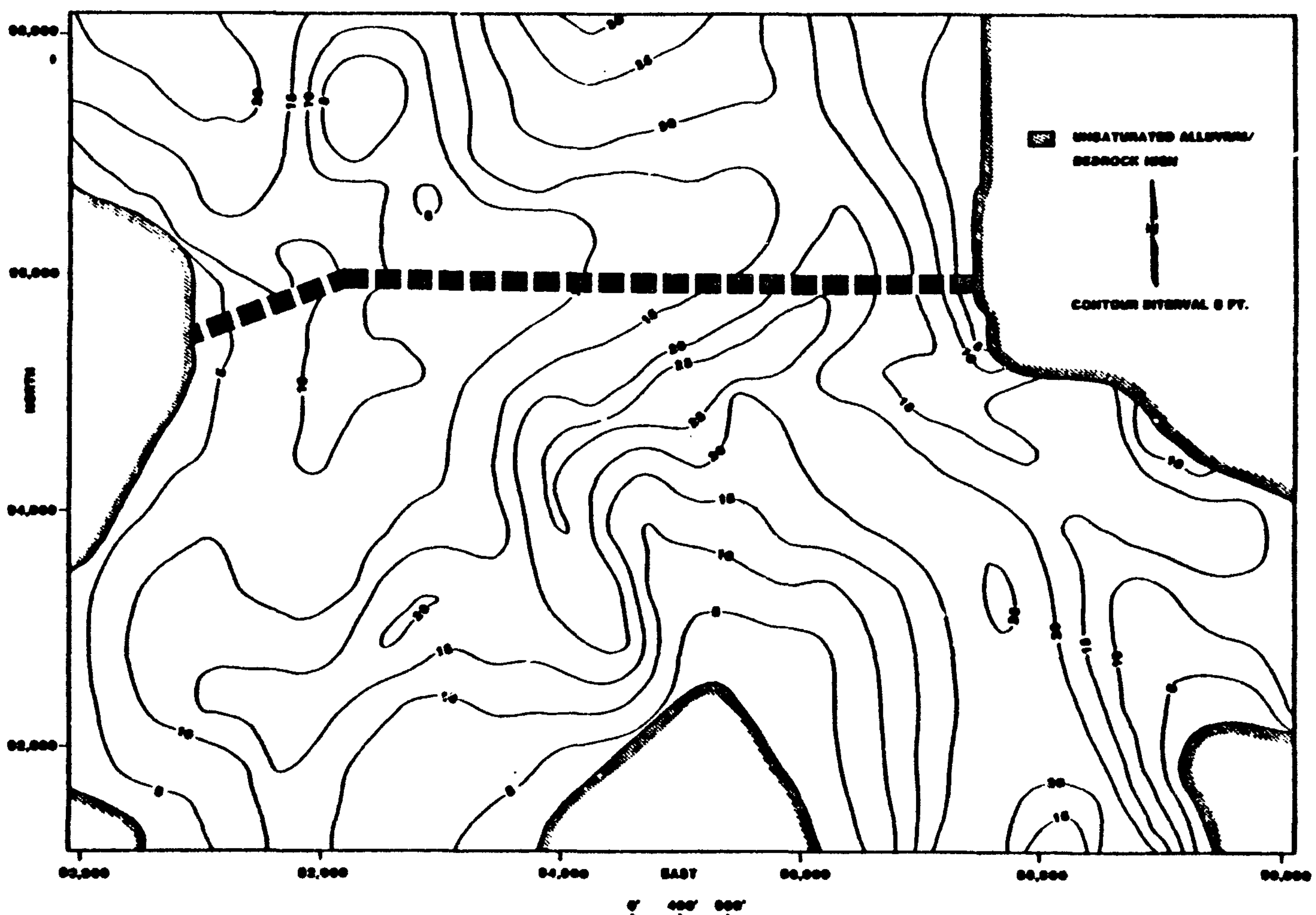
BARRIER LOCATION

CONTOUR INTERVAL 1 FT.

FIGURE 2-5

SATURATED THICKNESS OF ALLUVIAL AQUIFER

NORTH BOUNDARY AREA - RMA



BARRIER LOCATION

FIGURE 2-6

These water levels were compared with other historic water level measurements and were judged to be a reasonably good representation of steady state conditions. Hydraulic conductivities and specific yields were based on six pump tests performed by WES and two pump tests performed by ESA in 1980. Summaries of pump test results are shown in Table 2-5 and Table 2-6. Data from WES test Wells 2 and 3 were not used because of variable pumping rates. Calculated specific yields ranged from 0.35 to 0.01 and a vertically averaged value of 0.1 was used to best represent conditions near the dewatering and recharge wells. Specific yield is not an important factor in calibration of the model because it is not a function of steady state head distribution. Additionally, specific capacity data from the pilot barrier dewatering wells were used to check modeled hydraulic conductivities in the vicinity of those wells. As a result, calibration of the model is dependent on the hydraulic conductivities assigned each node and the accuracy of the modeled flows is, therefore, dependent on the validity of hydraulic conductivities determined from pump test data. The modeling technique forces fluxes throughout the system to balance so that hydraulic conductivities are correct relative to cells where pump test data were obtained when calibrated to observed steady state water levels.

2.2.4.6 The finite-difference model was calibrated using the inverse method. This method included the following steps:

(1) Development of steady state water levels which was accomplished by contouring the best available water level data for 202 observation wells distributed throughout most of the system. Resulting water level contours are shown on Figure 2-4.

(2) Trial values of hydraulic conductivity were estimated based on pump tests between Basin F and the North Boundary. All available pump test data were analyzed using the unconfined type curves of Newman (1975). Initial hydraulic conductivities for the model area were established using a model calibration procedure proposed by Hunt and Wilson (1974), and Day and Hunt (1977).

TABLE 2-5

SUMMARY

of

PUMP TEST RESULTS

in

ALLUVIUM, ROCKY MOUNTAIN ARSENAL

Test No.	Obs. Well	T (gpd/ft)	S_y
1032-1	1031	19,864	0.003
	1030	23,837	0.14
1032-2	1030	20,342	0.02
	1031	20,342	0.0027
Approx. Average for	1032	21,096	0.0414
1036-2	1033	18,794	0.01

NOTES:

Average k in vicinity of well 1032 = $\frac{21,096}{17}$ = 1,241 gpd/ft = 60,558 ft/yr

Average k in vicinity of well 1036 = $\frac{18,794}{11}$ = 1,709 gpd/ft = 83,377 ft/yr

T = transmissibility

S_y = specific yield

k = horizontal hydraulic conductivity of alluvium

SLUG TEST RESULTS FOR HYDRGOEOLOGIC
ASSESSMENT OF DENVER FORMATION SANDS
ALONG NORTH BOUNDARY

Pilot Boring No.	Satellite Boring No.	Screen Depth ft	Flow Type	Fit Compared to Type Curve	Storativity	Transmissivity cm^2/sec	Permeability cm/sec	Aquifer Thickness ft
965	965-1	42.0- 54.0	Confined	Good/Excellent	10^{-1}	2.46×10^{-2}	$.792 \times 10^{-4}$	10.0
	965-2	80.0- 90.0	Confined	Good	10^{-1}	0.020×10^{-2}	0.0079×10^{-4}	8.2
976	976-1	48.0- 53.0	Unconfined	Fair/Good	--	--	0.788×10^{-4}	3.0
	976-2	61.0- 66.5	Confined	Good	10^{-2}	0.408×10^{-2}	0.288×10^{-4}	5.5
977	977-1	46.0- 50.0	Confined	Fair	10^{-1}	0.198×10^{-2}	0.191×10^{-4}	4.0
	977-2	70.0- 77.0	Confined	Fair	10^{-2}	0.208×10^{-2}	0.115×10^{-4}	10.0
978	978-1	64.0- 74.0	Confined	Good/Excellent	10^{-1}	0.369×10^{-2}	0.142×10^{-4}	6.3
	978-2	105.0-110.0	Confined	Fair	10^{-5}	0.140×10^{-2}	0.108×10^{-4}	5.0
979	979-1	31.0- 35.0	Confined	Good	10^{-4}	147.0×10^{-2}	141.0×10^{-4}	4.0
	979-2	51.0- 64.0	Confined	Good	10^{-1}	0.576×10^{-2}	0.171×10^{-4}	11.2
	979-3	81.0-100.0	Confined	Good/Fair	10^{-2}	0.276×10^{-2}	0.056×10^{-4}	16.0
981	981-1	41.0- 45.0	Confined	Poor	10^{-4}	0.347×10^{-2}	0.334×10^{-4}	4.0
	981-2	70.0- 88.0	Confined	Good	10^{-2}	3.43×10^{-2}	0.736×10^{-4}	16.0
983	983-1	25.0- 30.0	Confined	Good	10^{-8}	1.99×10^{-2}	1.53×10^{-4}	5.0
	983-2	60.0- 65.0	Confined	Fair	10^{-8}	0.116×10^{-2}	0.089×10^{-4}	5.0
984	984-1	45.0- 53.0	Confined	Good/Excellent	10^{-2}	1.43×10^{-2}	0.69×10^{-4}	8.0
	984-2	70.0- 80.0	Confined	Fair/Good	10^{-2}	0.538×10^{-2}	0.208×10^{-4}	6.5
985	985-1	40.0- 58.0	Confined	Fair/Good	10^{-5}	23.0×10^{-2}	4.94×10^{-4}	20.0
986	986-1	35.0- 40.0	Confined	Fair	10^{-3}	0.25×10^{-2}	0.192×10^{-4}	(Jointed clay)
	986-2	52.0- 62.0	Confined	Fair/Good	10^{-3}	0.433×10^{-2}	0.167×10^{-4}	3.0
987	987-1	75.0- 90.0	Confined	Fair	10^{-1}	8.60×10^{-2}	2.21×10^{-4}	14.0
991	991-1	47.0- 52.0	Unconfined	Good/Fair	--	--	0.133×10^{-4}	3.0
	991-2	68.0- 75.0	Confined	Fair	10^{-1}	3.34×10^{-2}	0.761×10^{-4}	7.0
	991-3	85.0-103.00	Confined	Good/Excellent	10^{-1}	1.65×10^{-2}	0.355×10^{-4}	17.0

Note: J.H. May, D.W. Thompson, P.K. Law, R.E. Wahl WES Working Draft (1980)

TABLE 2-5a

TABLE 2-5b
SUMMARY OF PUMP TEST RESULTS IN
DENVER SANDS, ROCKY MOUNTAIN ARSENAL

Test No.	Obs. Well	T (gpd/ft)	S	k'/m'	m'	k' (gpd/ft^2)	k' (ft/yr)
1041-1	1042	176	0.0004	0.000176	15	0.00264	0.129
1041-1	985	196	0.00015	0.000082	15	0.00123	0.060
1041-1	1043	243	0.000026	N/A		N/A	N/A
1041-1	1041	148	N/A	(recovery test in pumped well)			
Approx. Average		200	0.0001				
1045-1*	1018*	754*	0.0042	(obscured by boundary effects)			
1045-1*	1046*	682*	0.0051	(obscured by boundary effects)			
	*(Test aborted because constant pumping rate not maintain, results unreliable.)						
1045-2	1018	234	0.0027	(obscured by boundary effects)			
1045-2	1046	184	0.0044	(obscured by boundary effects)			
1045-2	1045	202	N/A	(recovery test in pumped well)			
Approx. Average		200	0.0036				

NOTES:

Average k in vicinity of well 1041 $= \frac{200}{24} = 8.3$ gpd/ft2 = 405 ft/yr

Average k in vicinity of well 1045 $= \frac{200}{17} = 11.8$ gpd/ft2 = 576 ft/yr

Average $k_{(horiz)}$ Denver Sands = 10 gpd/ft^2 = 488 ft/yr

Average k' Denver Shale = 0.019 gpd/ft^2 = 0.094 ft/yr

T = transmissibility
S = storage coefficient
m' = saturated thickness of confining layer (Denver Shale)
k' = vertical hydraulic conductivity of confining layer (Denver Shale)
$k_{(horiz)}$ = hydraulic conductivity of aquifer (Denver Sands)

TABLE 2-6

SUMMARY OF TRANSMISSIVITY AND PERMEABILITY DATA

Well No.	Avg. Transmissivity (gpd/ft)	*Effective Saturated Thickness (feet)	**Hydraulic Conductivity (gpd/ft)
WES No. 4	25,000	12.05	2,075
VISPI 529	74,000	7.57	9,841
VISPI 345	25,000	11.35	2,203
VISPI 368	41,500	3.5	11,857
VISPI 549	9,550	7.0	1,364
VISPI 548	17,000	7.0	2,429
ESA 1032	21,000	15.6	1,346
ESA 1036	19,000	8.33	2,281

* Effective saturated thickness does not include clays and silts. This saturated thickness is used to calculate hydraulic conductivity of sand and gravel aquifer $\frac{\text{Transmissivity}}{\text{saturated thickness}}$ = hydraulic conductivity.

** These hydraulic conductivities for 1032 and 1036 are different from those shown in Table VI-1A because the effective saturated thickness was used instead of the total saturated thickness used in Table VI-1A.

NOTE: Specific yield values are not shown because they were not used in the model. A uniform value of 0.1 was used for all nodes.

(3) Using the above data, the analysis was then carried out until a steady state condition was reached.

(4) A comparison of the observed and calculated water levels was then made and the hydraulic conductivities adjusted until a suitable match was obtained between the observed steady state water levels established in (1) and those obtained from the model using adjusted hydraulic conductivities. Resulting model hydraulic conductivities are represented by transmissivity contours shown on Figure 2-7 (transmissivity = hydraulic conductivity times the saturated thickness).

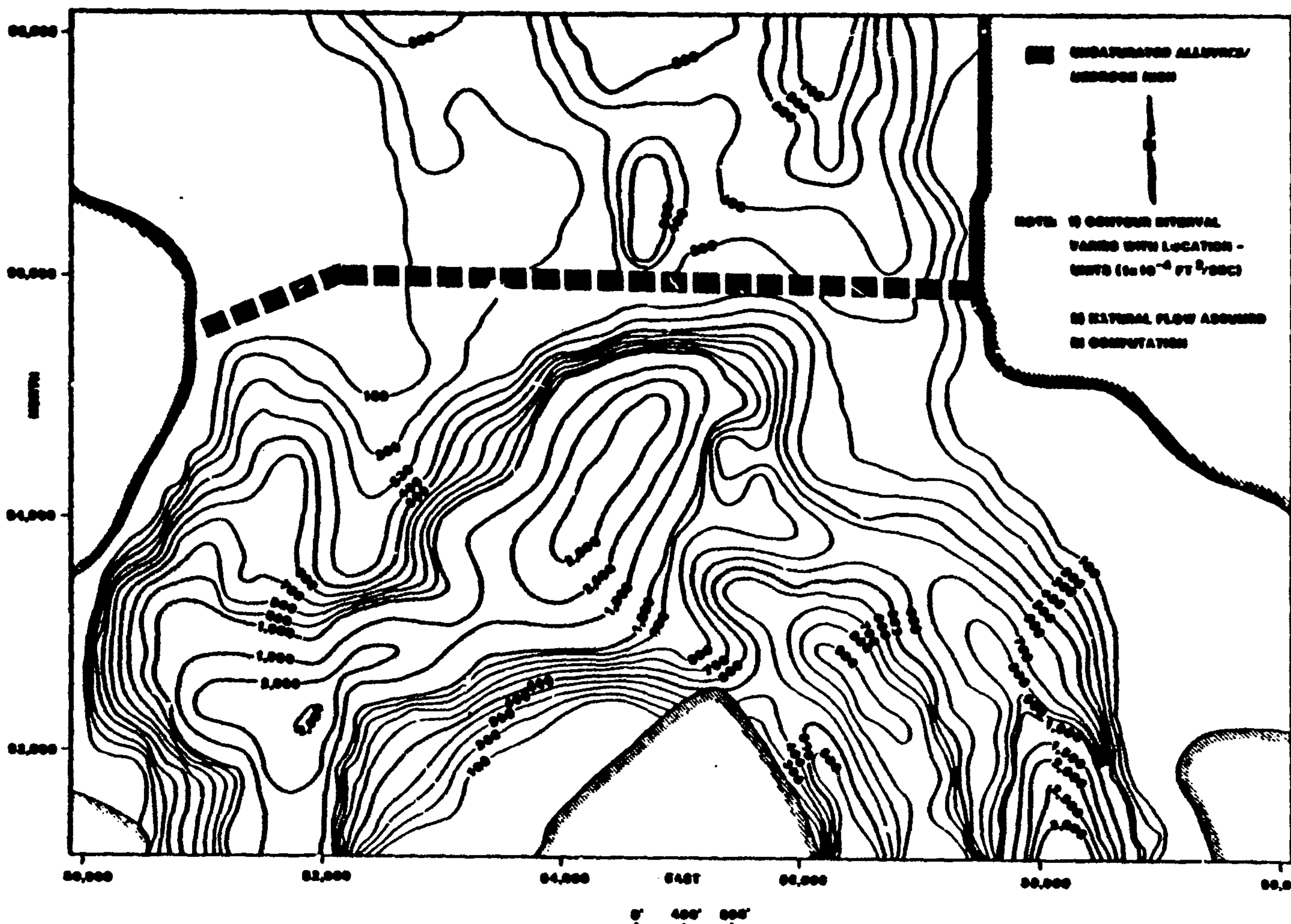
2.2.4.7 After calibration, 98.4 percent of the active nodes were within 2 feet of observed water levels, 96.7 percent were within 1.5 feet and 93.4 percent were within 1 foot. Considering the local seasonal variation and the scarcity of data in some areas, this calibration was judged to be adequate for design purposes. The simulated steady state ground water levels are shown on Figure 2-8.

2.2.5 <u>System Simulation</u>. The natural flow through the system was computed by the model to be 440 gpm. Once the barrier was in place somewhat more than this flow would have to be pumped and recharged because of several factors:

(1) In the long term, pumping will lower ground water levels in the proximity of the dewatering wells and will induce more flow through the system because of the steeper gradients induced by well drawdowns.

(2) At the initiation of pumping, the influence of each well is small and flow will bypass the pumping wells causing a rise in ground water levels near the barrier. If the wells are extracting flow equal to the natural flow rate, some water would come from storage upstream of the dewatering wells. On the downstream side of the dewatering wells (near the cutoff wall), flowing water would accumulate. To prevent this rise in ground water levels during early time, pumping must capture the natural flow plus water taken from storage.

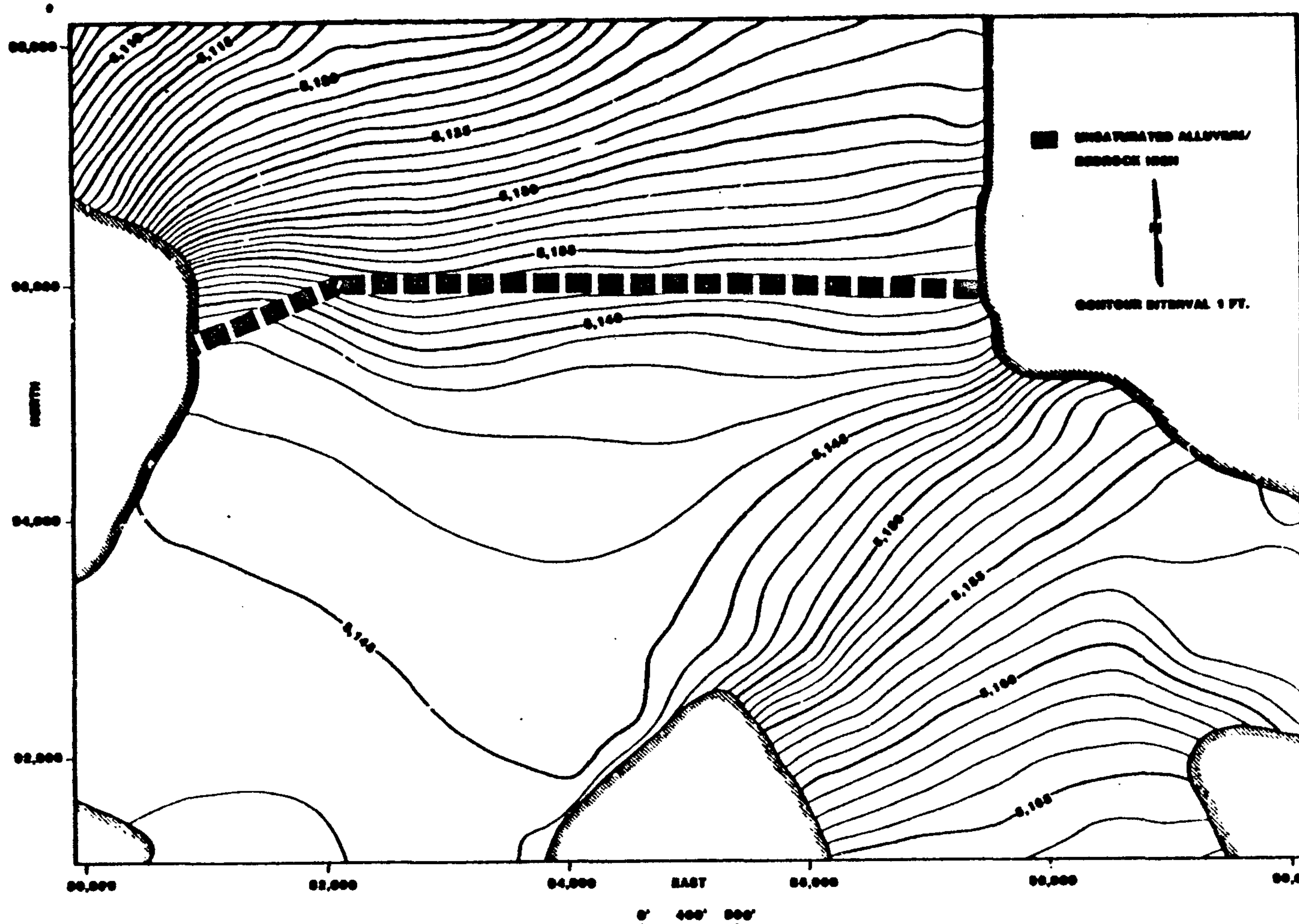
TRANSMISSIVITY CONTOURS



BARRIER LOCATION

FIGURE 2-7

GROUNDWATER ELEVATIONS



BARRIER LOCATION

FIGURE 2-8

(3) It is desirable to lower water levels in the aquifer between the pump wells and the cutoff wall because in the event of failure of dewatering wells, the dewatered zone serves as a storage buffer against flooding. To create this ground water storage buffer, pumping must exceed natural flow rates.

(4) While system flows were computed as precisely as possible, both the total system flow rate and local rates can be in error. As a precaution against flooding, a safety factor of ± 50 percent is included in design pumping rates.

2.2.5.1 Design dewatering and recharge rates were based on natural flows plus 10 percent. Natural flows were calculated for 100-foot segments (each cell) along the barrier. The water was distributed to each dewatering and recharge well based on its likely zone of influence. The 10 percent additional pumping was found to be sufficient to prevent significant flooding based on the simulation model. It should be noted that the design pumping rates are a best estimate based on interpretation of pump test data. Since these values may have to be adjusted during operation, each pumping well is designed to have a pumping range of ± 50 percent of its design value. This design flexibility also will allow for an increase in individual pumping rates to compensate for individual well shutdowns for maintenance or failure.

2.2.5.2 Figure 2-9 shows the simulated steady state ground water surface resulting from the pumping and recharge system. Steady state conditions would be reached in approximately four and one-half years assuming flow into the modeled area remains reasonably constant.

2.3 __INVESTIGATIONS DURING CONSTRUCTION__. Investigations and inspections during construction included the visual logging of the well borings (Plates 19-42), geophysical logging of some wells (Appendices A and B), pump testing new wells (Tables 2-7, 2-8, 2-9), inspection of excavated slurry trench materials, contractor slurry testing, backfill gradation testing, and site piezometer readings (Table 2-10).

STEADY STATE GROUNDWATER ELEVATIONS

SIMULATION OF DEWATERING AND RECHARGE WELL OPERATION

NORTH BOUNDARY AREA - RMA

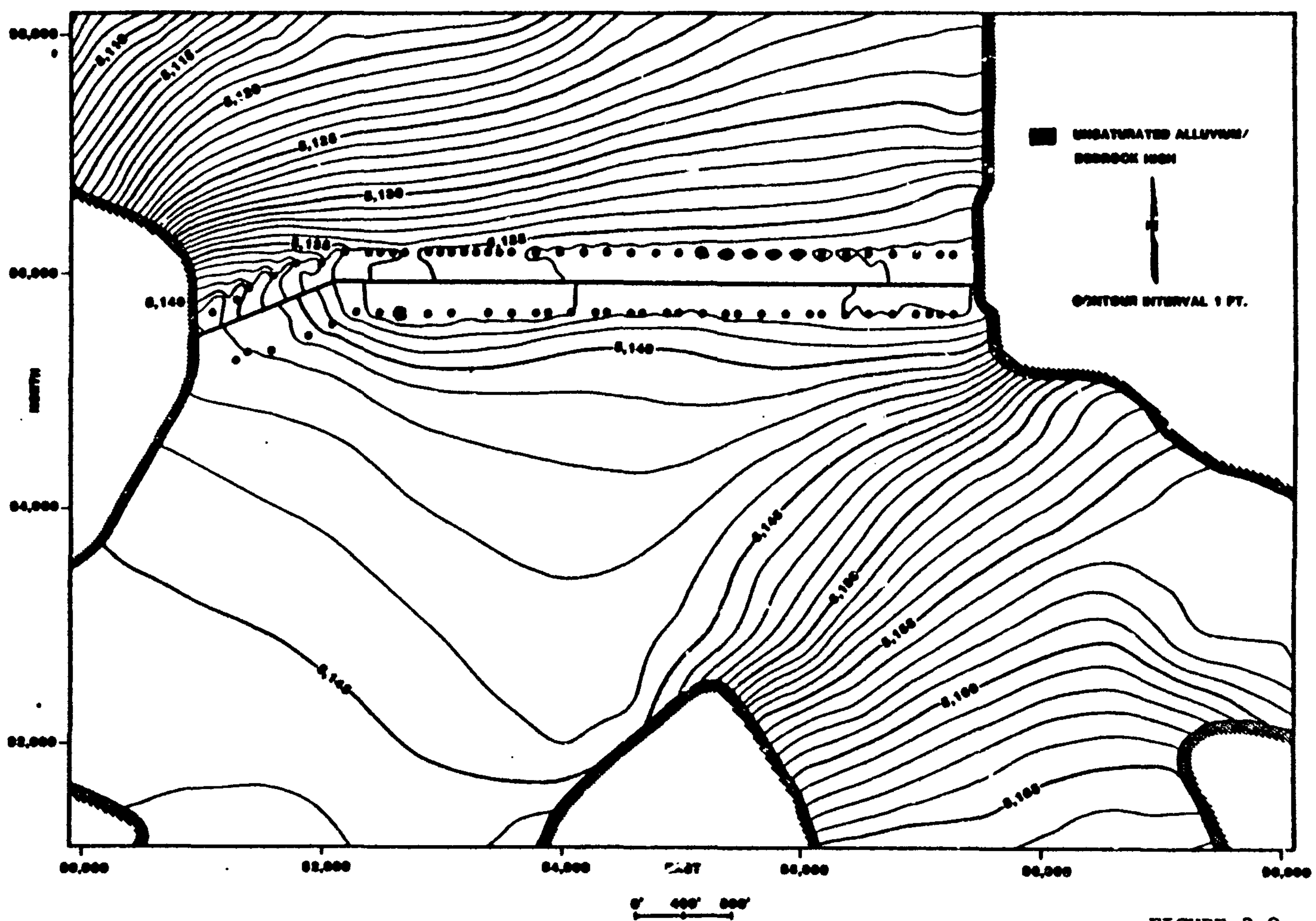


FIGURE 2-9

2.3.1 **Well Testing and Development**. There were two types of developing procedures and a type of percolation test for the recharge wells as described below. Well testing data are shown on Tables 2-7, 2-8, and 2-9.

2.3.1.1 The alluvial dewater and recharge wells were developed as follows: air-water jetting for at least three prescribed cycles, 2 hours of pumping, disinfection with sodium hypochlorite to a concentration of 1000 ppm in water for 24 hours, 2 hours clean pumping, followed by a 4-hour pump test measuring water levels, pumping rate, and sand content. Additionally, the recharge wells were then filled with water to riser pipe height with a measured amount of water, and then the time taken to reach original static level was recorded.

2.3.1.2 Testing and development of the Denver Formation sandstone dewater wells followed the same procedures used on the alluvial dewater wells.

2.3.1.3 Both the shallow and deep monitoring wells followed similar developing and testing procedures, except that they were bailed and swabbed instead of jetted due to the plastic pipe casing. After 24 hours of disinfection, these wells were pump tested 2 hours, and water levels, pumping rate, and sand content recorded.

2.3.1.4 None of the wells had to be abandoned, and no temporary casing was used during construction. Denver Formation sandstone dewater wells and monitoring wells were logged with electric and natural gamma ray equipment (Appendices A and B). The geophysical logs were used to properly place screens in a permeable sandstone of the Denver Formation. Resistivity and natural gamma logs tended to be the most beneficial, while the spontaneous potential logs had questionable results.

2.3.2 **Trench Investigations**. As the slurry trench was excavated to the minimum excavation line shown on Plates 19 through 30, undisturbed samples

TABLE 2-7

DEWATER WELL TESTING

Well #	Pump Test Capacity (GPM)	Design Estimate Capacity (GPM)	Well #	Pump Test Capacity (GPM)	Design Estimate Capacity (GPM)	Well #	Pump Test Capacity (GPM)	Design Estimate Capacity (GPM)
DW-7	9	16.2	DW-23	35	18.6	DW-39	2	2
DW-8	17	16.5	DW-24	35	18.9	DW-40	2	1
DW-9	16	17.9	DW-25	45	19.1	DW-41	1	1
DW-10	24	14.8	DW-26	35	10.6	DW-42	6	1
DW-11	30	14.8	DW-27	15	10.0	DW-43	.25	1
DW-12	26	20	DW-28	15	9.0	DW-44	.13	1
DW-13	34	23	DW-29	12	6.0	DW-45	.13	1
DW-14	34	21.9	DW-30	.5	1	DW-46	.25	1
DW-15	34	20.8	DW-31	1	2	DW-47	.13	1
DW-16	35	20.1	DW-32	24	3	DW-48	.13	1
DW-17	42	26	DW-33	36	5.5	DW-49	5	2
DW-18	51	26.2	DW-34	40	4	DW-50	5	2
DW-19	10	25.7	DW-35	10	4	DW-51	.25	2
DW-20	65	23.9	DW-36	1	5	DW-52	.13	1
DW-21	65	15.3	DW-37	1	2	DW-53	.13	2
DW-22	60	13.8	DW-38	4	2	DW-54	.13	2

Note: Wells DW-1 through DW-7 placed in pilot system.
Wells DW-36 through DW-54 are Denver Sands wells.

TABLE 2-8

RECHARGE WELL TESTING*

Well #	Pump Test Capacity (GPM)	Static Water Level Feet Below T.O.C.	Duration of Recharge Test (Minutes)	Well #	Pump Test Capacity (CPM)	Static Water Level Feet Below T.O.C.	Duration of Recharger Test (Minutes)
RW-13	23	16.2	40	RW-26	65	11.1	5
RW-14	5	10.6	45	RW-27	20	12.4	15
RW-15	17	10.1	23	RW-28	25	13.2	45
RW-16	30	9.9	25	RW-29	.5	18.5	60
RW-17	36	9.7	30	RW-30	3	26.2	35
RW-18	34	6.1	10	RW-31	25	31.1	50
RW-19	7	6.7	35	RW-32	1	11.25	24 hrs 30 min
RW-20	19	7.1	30	RW-33	.13	9.0	24 hrs 25 min
RW-21	34	6.7	25	RW-34	.13	9.0	24 hrs 20 min
RW-22	34	6.1	30	RW-35	.13	8.0	24 hrs 15 min
RW-23	65	6.2	5	RW-36	.75	9.65	24 hrs
RW-24	65	8.25	5	RW-37	15	10.0	95
RW-25	65	9.5	5	RW-38	3.5	11.0	90

* Wells RW-1 through RW-12 placed in pilot system.

TABLE 2-9

MONITOR WELL TESTING

Well #	Test # Capacity (GPM)	Water Level Before Pumping (FT)	Water Level After Pumping (FT)	Test #2 Capacity (GPM)	Water Level Before Pumping (FT)	Water Level After Pumping (FT)
M-1	.5	11.9	23.7	.5	11.9	23.6
M-2	4	12.8	18.3	4	12.8	18.3
M-3	4	13.7	17.6	4	13.7	13.7
M-4	10	11.4	13.5	10	11.4	13.5
M-5	8	10.3	17.4	8	10.3	17.5
M-6	8	12.0	22.1	10	12.0	22.0
M-7	10	8.7	11.3	10	8.7	11.3
M-8	10	10.0	11.6	10	10.0	11.6
M-9	10	12.7	17.2	10	12.7	17.2
M-10	.13	14.6	25.0	.13	14.6	24.9
M-11A	2	5.5	81.3	2	5.5	81.3
M-11B	6	7.3	94.7	6	7.3	94.7
M-12	5	12.5	30.1	5	12.5	30.0
M-13	4	18.1	28.3	4	18.1	28.3
M-14	1	18.7	34.2	1	18.7	34.2
M-15A	.5	13.2	93.4	.5	13.2	93.4
M-15B	.5	17.3	61.2	.5	17.3	61.2
M-16	.5	18.1	19.0	.5	18.1	19.0
M-17	10	10.0	17.2	10	10.0	17.2
M-18A	1.5	98.4	129.4	1.5	98.4	129.4
M-18B	2	9.3	47.3	2	9.3	47.4
M-19	10	12.1	20.0	10	12.1	20.0
M-20A	2	14.5	56.4	2	14.5	56.3
M-20B	2.5	12.1	91.3	2	12.1	91.3
M-21	10	6.5	12.0	10	6.5	12.0
M-22	2	11.1	19.0	2	11.1	19.0
M-23	5	8.4	10.0	5	8.4	10.1

TABLE 2-9 Continued

MONITOR WELL TESTING

Well #	Test # Capacity (GPM)	Water Level Before Pumping (FT)	Water Level After Pumping (FT)	Test #2 Capacity (GPM)	Water Level Before Pumping (FT)	Water Level After Pumping (FT)
M-24	10	11.3	13.2	10	11.3	13.2
M-25	10	8.5	9.1	10	8.5	8.4
M-26	10	7.0	8.7	10	7.0	8.7
M-27	10	3.4	4.0	10	3.4	4.0
M-28	.5	16.5	27.4	.5	16.5	27.4
M-29	10	5.0	11.8	10	5.0	11.8
M-30	10	7.5	16.8	10	7.5	16.7
M-31	10	11.0	15.0	10	11.0	15.0
M-32	10	7.3	8.4	10	7.3	8.4
M-33	10	5.2	9.1	10	5.2	9.1
M-34	10	4.0	6.1	10	4.0	6.2
M-35	10	7.1	7.9	10	7.1	7.9
B-36	10	8.4	9.7	10	8.4	9.7
M-37	.5	20.8	21.0	.5	20.8	21.0
M-38A	1	13.4	83.0	1	13.4	83.0
M-38B	2	90.0	208.3	2	90.0	208.4
M-39	.5	23.4	23.5	.5	23.4	23.5

were taken of the bottom material at 24 to 30-foot intervals. The sampler was attached to the backhoe bucket on a tooth shank at the time of sampling, and provided an adequate sample in all but the hardest bedrock, when the backhoe arm could not provide enough force. The inspection of undisturbed samples was augmented by the inspection of bucket samples every 10 feet. If any sample indicated a fractured zone, heavy weathering, sandstone, or lignite, the excavation was taken deeper to a less permeable material.

2.3.3 Slurry Testing. The slurry used in the excavation and backfill of the barrier was a mixture of ultrafine natural sodium bentonite and treated sewage water. Slurry properties were tested following the American Petroleum Institute (API) Code RP 13B. Methylene blue absorption, viscosity, density, and filtration tests were initially run four times a day with the viscosity used to control the initial mixture in the storage pond. Testing revealed that under normal conditions, the slurry properties changed very little, so tests were later performed only when adding slurry to the trench or when precipitation or other factors might have caused a change in the trench or holding pond. When there were delays in the trenching longer than 2 days, the viscosity of the slurry in the trench and storage pond tended to increase, requiring occasional additional testing. Ground-water seeping into the pond or precipitation tended to reduce the viscosity of the slurry, also requiring additional testing. Once in the trench, slurry was tested for density and viscosity at 50-foot intervals and at 10-foot depths except near the working face of the trench. These tests were performed at the trench site. The methylene blue absorption and filtration tests were run in the onsite ECI lab facility.

2.3.3.1 The methylene blue absorption test had no maximum or minimum established, so the tests were performed only for general information. The results throughout the project did not vary significantly from the initial tests, so no major change was observed in the condition of the slurry. Filtration testing results were never greater than 16cc of water loss at 100 psi in 30 minutes, well below the allowed maximum of 20 cc under the same conditions. The density of the slurry in the trench was required to be between 70 and 85 lb/cu.ft. Viscosity was at least 40 Marsh seconds,

except under heavy ground-water conditions or precipitation, as previously described.

2.3.3.2 Adjustments were made in the slurry mixture as required to meet the parameters. Only the density and viscosity varied from the limits, under conditions described previously. The slurry was returned to its limits by adding more suitable slurry to the trench and by normal agitation during the excavation process. This worked well on the densities and viscosities both above and below the limits. Normally, the addition of new slurry during excavation precluded the need for drastic adjustments in the in-trench slurry mixture.

2.3.4 Backfill Testing. Backfill consisted of a mixture of slurry and excavated material from the trench, blended to the consistency of medium slump concrete. Slump tests were performed on the backfill mixture once or twice a day, depending upon the amount of backfilling to be done. A standard slump cone test, using ASTM C 143-74 procedures, was performed, with an allowable range from 2 to 5 inches. Slump was generally in the 2-1/2"-3-1/2" range. Gradation tests were taken daily on each portion of 300 cubic yards of fill placed in the trench. Procedures for the gradation analyses were according to ASTM C 136-76, and were to conform to the following requirements:

Screen Size or Number U.S. Standard	Percent Passing by Dry Weight
1-1/2 inch	90-100
3/4 inch	80-100
No. 4	50-100
No. 30	25-70
No. 200	10-25

Select material was to be blended as necessary with the backfill in order to meet the gradation requirements.

2.3.5 Piezometer Readings. When it was determined that the treatment plant would not be operational at the time the barrier was in place, a program was developed for reading water level rise on the upgradient side of the barrier. Modeling studies had shown that in the absence of pumping, surface flooding could occur in lower areas, as well as mixing of the contaminant plume. Readings taken from 4 June 1981 to 31 August 1981, during the excavation of the trench and the shutdown of the treatment plant, indicated a very slow rise in ground-water level until the barrier was completed. The rise after that time increased markedly, with surface flooding of ground water evident in the low area just west of First Creek. Table 2-10 shows the rapid rise near completion of the barrier. Water levels continued to rise in the area, and the bog began to dry up, until the treatment system was operational. Although the action of damming water behind the barrier may have detrimentally caused surface flooding and contaminant plume mixing, it did show that the barrier was effective and that the aquifer had a significant storage capacity in case of temporary shutdowns of the dewatering system.

TABLE 2-10

WATER LEVEL READINGS

DATE REC'D	# 29	# 33	# 120	# 320A	# 23-45	# 21	# 14	# 24-41	# 941	# 24-150	E2D	# 1HD	# 2HD
	MAY 1, 1981 - 1st phase of the slurry trench was completed												
4 June 81	16.00'	24.00'	11.5'	8.00'		13.00'	16.00'						
12 June 81	17.2'	24.7'	11.7'	8.00'		12.8'	15.4'	6.2'	4.6	8.0	5.9		
Finished Trench to 38+10 15 June 81													
19 June 81	17.20'	24.75'	11.45	8.00		12.50	14.70	6.60	4.80	8.05	6.20		
26 June 81	17.25'	24.[illegible]'	11.39	8.18		12.32	14.54	7.05	5.36	8.49	6.75		
1 July 81	17.15'	24.71'	11.16	7.74		12.48	14.53	6.98	4.97	7.98	6.44		
9 July 81	17.26'	24.63'	10.94	7.18	12.68	12.07	14.44	6.67	5.07	7.45	6.48		
17 July 81	17.16'	24.70'	10.94	7.32	12.64	12.05	14.24	5.73	5.15	6.75	6.43		
24 July 81	17.27'	24.63'	10.85	7.67	12.71	11.96	14.22	5.43		6.71	6.49		
30 July 81	17.25'	24.65'	10.87	7.58	12.75	11.93	14.27	5.19		6.43	6.46	1.55	3.11
6 Aug 81	17.16'	24.68'	11.02	7.76	12.83	12.02	14.34	5.27		6.43	6.65	1.60	3.15
10 Aug 81	17.26'	24.73'	10.86	7.75	12.82	11.90	14.22	5.02		6.34	6.40	1.45	2.90
Finished Trench 12 August 81													
14 Aug 81	17.24'	24.73'	10.83	7.62	12.75	12.88	14.05	4.56		6.13	6.04	1.05	2.42

TABLE 2-10 (Cont'd)
WATER LEVEL READINGS

DATE READ	# 29	# 33	# 120	# 320A	# 23-45	# 21	# 14	# 24-41	# 941	# 24-150	E2D	# 1HD	# 2HD
17 Aug 81	17.23'	24.72'	10.75	7.56	12.95	11.91	14.02	4.42		6.02	5.85	Ground Level	2.20
19 Aug 81	17.32'	24.64'	10.71	7.60	12.81	11.89	14.00	4.41		6.25	5.82	Ground Level	2.23
21 Aug 81	17.22'	24.68'	10.77	7.56	12.78	11.75	13.84	4.31		6.01	5.78	Ground Level	2.07
31 Aug 81	17.15'	24.81'	10.70	7.44	12.78	11.57	13.67	Ground Level		5.79	5.66	Ground Level	Ground Level

All measurements taken
from top of casing

Location Designated on C-1

CHAPTER 3. - GEOLOGY

3.1 PHYSIOGRAPHY. Rocky Mountain Arsenal is located within the Colorado Piedmont section of the Great Plains physiographic province and is characterized by late mature to old elevated plains and low rolling topography. The site itself is on the eastern edge of a broad valley of the South Platte River, east of the foothills of the Front Range of the Rocky Mountains. Topographic relief across the entire Arsenal is approximately 200 feet, with the land surface generally sloping northwest toward the South Platte River (see Figure 3-1).

3.2 DESCRIPTION OF OVERBURDEN. Overburden consists of silts, sands, clays, gravels, and some cobbles, in various combinations, overlying bedrock in the area. Plates 19 through 30 indicate the types of materials encountered through the project area. Just above the bedrock, the soils are Quaternary alluvial deposits ranging from 8 to 40 feet in thickness, with irregular, braided channel deposits and lenses characteristic of alluvium. Much of these deposits are not saturated and the saturated thickness varies from 0 to a maximum of 30 feet in the North Boundary area. Beneath some areas of other parts of the arsenal the saturated thickness of these deposits is considerably greater. Alluvial deposits are often referred to as the alluvial aquifer or upper aquifer. The alluvial deposits represent ancient stream valleys of the South Fork Platte River drainage system. These deposits underlie areas along presently active drainages such as First Creek and occur as terrace deposits in areas such as between Basin F and the North Boundary. In other areas these deposits are absent. These deposits are incised as generally broad but irregular channels into the Denver Formation. Sands with gravels and some cobbles predominate in or near the deeper channels with a tendency for accumulations of predominately silts and clays near the margins. Also, finer grained materials tend to be present in the upper portion of these deposits because more recent deposition has resulted from smaller streams with less load capacity than during the initial stages of deposition. The sands and gravels consist of crystalline rocks indicating a source in the

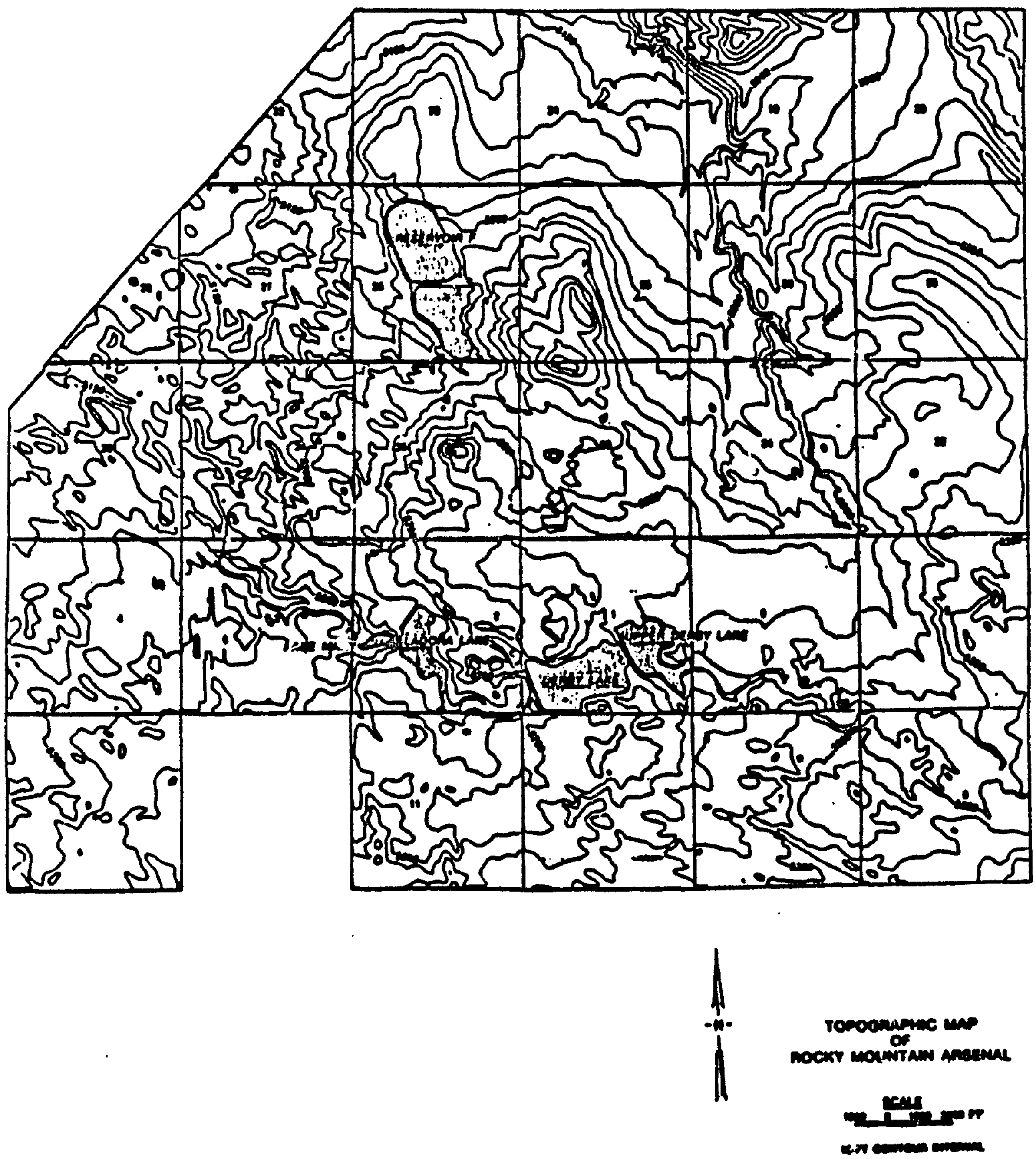


Figure 3-1

Front Range of the Rocky Mountains to the west. Occasional calcareous cemented zones in this alluvium range from several inches to 8 feet in thickness and form SW-NE trending lenticular beds near the base of the alluvium in the area of the bog (Plate 13). Cemented zones were more extensive than the boring plan indicated, causing more difficult well drilling and trench excavation. The trench profile on plate 24 shows the location of the highest concentrations of cementation. The cemented material was primarily quartz and feldspar sand grains cemented with calcite into a fairly competent mass, with about 7 percent porosity and 35 percent by weight calcite, and a strength of up to 1,580 psi as determined from unconfined compression testing. The alluvium is overlain in places by deposits of windblown silts and sands, especially in the Henderson Hill area at the eastern end of the barrier. This area is a topographic high consisting of 20 to 40 feet of wind blown sand, which pinches out near First Creek. Aeolian deposits are found over much of the remainder of the NBE area.

3.3 **BEDROCK STRATIGRAPHY**. The Denver Formation is the bedrock unit beneath RMA. It consists of shales, claystones, sandstones, and conglomerate that are generally impervious. In the north boundary area, the Denver Formation consists of predominantly gray to gray brown shale or claystone, with irregular, discontinuous sandstone lenses.

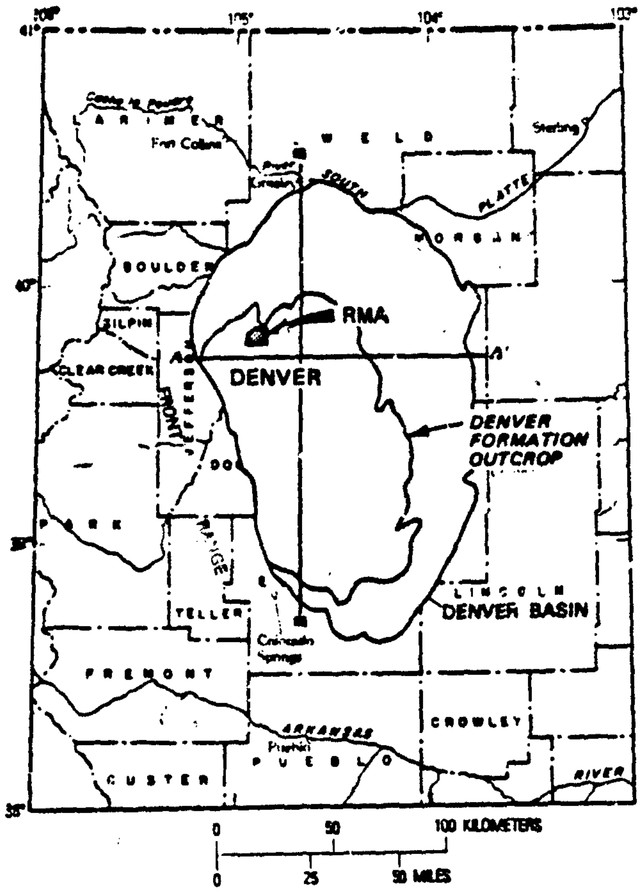
3.3.1 Studies by WES (1980) indicate that the Denver Formation is 250 to 400 feet thick in the vicinity of the NBE, and therefore, this formation is the only bedrock unit of concern for this study. All further references to bedrock in this report refer to the Denver Formation.

3.3.2 The Denver Formation is of probable Paleocene age consisting of sequences of deltaic deposits. The depositional environment resulted in a predominance of fine grained materials rich in organic matter. Lignite seams have been reported nearby and fragments of lignite were encountered in boreholes during this study. Interbedded with the fine grained sediments are sand deposits and silty sands that apparently represent stream channel deposits that were probably deposited in meandering channels and adjacent portions of flood plains.

3.3.3 The sands of the Denver Formation constitute important aquifer zones in the Denver Basin and yield water to domestic, municipal and industrial wells. Individual sand beds are lens shaped in cross section but may extend for long distances along sinuous channels. Interweaving of these channels provides good regional lateral interconnection by occasional overlapping of channel deposits. Thickening with vertical overlapping or stacking provides good vertical interconnection over wide areas although this vertical interconnection may be poor at a given location. As a result, individual sand beds by themselves are not important aquifers, but rather groups of sand beds act as aquifer zones that respond or act much as a single aquifer. This condition is typical of the major ground water basins of much of the Western U.S. and the Atlantic and Gulf coastal plains where they are composed of deep alluvial fill.

3.4 BEDROCK STRUCTURE. RMA is located near the northwestern flank of the Denver Basin, an oval structural basin measuring approximately 120 by 70 miles. This basin is filled with about 15,000 feet of sedimentary rocks. The bedrock at RMA is a thick sequence of Paleocene and Cretaceous deltaic and alluvial deposits with gentle regional dips to the southeast, toward the axis of the Denver Basin.

3.4.1 In the late Cretaceous and early Tertiary times, major deposition occurred in the Denver Basin. In the Tertiary Period, the Laramide Orogeny began, resulting in uplift of the whole area and the development of the Rocky Mountains to the west of the site. In time, the uplift caused erosion which removed most of the Tertiary sediments and exposed the late Cretaceous sediments. The remnants of this erosional period are pediments formed along the eastern plains near the foothills. With the retreat of the glaciers in the Quaternary period, massive erosion of the Cretaceous formations continued, shaping the present bedrock topography in the RMA area.



Rocky Mountain Arsenal in relation to the Denver Basin and outcrop pattern of Denver formation (Robson and Romero 1981)

Figure 3-2

3.4.2 No significant faulting has been noted at RMA, although some seismic activity in basement rock was associated with the deep well disposal program in the mid-1960's. The Denver Formation is jointed and fractured in the vicinity of the proposed barrier, as observed in sample cores and described in borehole logs. The clay shales or claystones are relatively massive and do not exhibit shale partings. They are not fissile. Joints and fractures are probably related to stress relief due to unloading by erosion and perhaps more important, due to dessication resulting in contraction cracks. The upper part of the unit, especially in the weathered zone is often classified as intensely fractured or crushed. This is probably not due to tectonic forces, but is probably related to drying. These materials were probably too dense to form regular mud cracks but instead formed irregular hairline fractures with a close spacing. Stress relief perhaps also played a role in this type of fracturing, since planar and wide space joints are present with some evidence of shearing. Iron staining was noted on fracture surfaces which indicates the joints and fractures were open enough to transmit water when the rocks were unsaturated and an oxidizing environment existed.

3.4.3 Unconfined compression tests were performed on core samples of the Denver Formation sandstone to indicate zones where difficult excavating would be encountered which might require blasting. The resulting shear strengths (S_u) are shown in some of the slurry trench and well profile plates, with values as high as 410 psi as shown in boring 1017.

3.5 BEDROCK WEATHERING. Along the barrier alinement, bedrock is weathered to depths ranging from 2 to 25 feet below the erosional surface of the formation. Weathering is gradational with color changes from shades of brown in the weathered zone to gray colors in the unweathered materials. This weathering indicates the erosional surface of the Denver Formation has been exposed to air and dessication permitting oxidation and decomposition of mineral constituents. This suggests that the weathered zone was unsaturated during the geologic past, during the Tertiary Period or possibly early Pleistocene.

3.5.1 The degree of weathering, freshness, and fracturing of the bedrock during construction was determined by examination of trench bottom samples and b· ing samples. Trenching operations frequently extended 1 to 3 feet deeper than the minimum excavation line due to fracturing and weathering of the Denver Formation near the bedrock surface. The Denver Formation sandstones at the north boundary frequently contained yellow-brown stained weathering zones near the base of blue-gray unweathered zones, especially in the bog area. These zones were slightly softer than the blue-gray sandstone and appeared to be slightly more permeable. These areas contained numerous pockets of clay and loose fine grained sands. During excavation, the alluvium-sandstone contacts were distinct over the site, but alluvium-claystone contacts were frequently ambiguous due to the similar characteristics of weathered claystone and the overlying alluvium.

3.6 GROUND-WATER HYDROLOGY. At the NBE area of RMA, it is reasonable to separate the regional flow system into two subsystems based on geology. The Quaternary Alluvium in this area is predominantly underlain by clay-shales, siltstones and sandstones of the Denver Formation which form a permeability barrier.

3.6.1 The shallow alluvial aquifer is composed of the sand, gravel, clay, and silt as described in Paragraph 3.2., and is the most used aquifer in the Denver area. The flow of water through this aquifer generally conforms to the bedrock surface, which slopes from southeast to northwest.

3.6.1.1 The fluvial deposits are probably related to an ancestral tributary of the South Platte River and are at least in part, terrace deposits left at higher elevations after continued down cutting by this stream. This is apparent in that the primary channel deposits trend from Basin F to the North Boundary rather than along the alluvial valley of First Creek further east. Contours on the base of the alluvial deposits (bedrock contours, Plate 4) show that the First Creek valley was a tributary to the main ancestral channel. These channels converge about 2000 feet south

of the proposed barrier alinement and the main channel crosses the boundary between the present channel of First Creek and the bog. A bedrock high to the west of the channel restricts the contaminated ground water from flowing northwest. Flow paths in the alluvial aquifer converge at the North Boundary. The western flow path passes beneath the eastern part of Basin F and trends northeasterly to the North Boundary. The eastern flow path has a northerly trend along First Creek. After these flow paths cross the boundary, they split into north and northwesterly trends to the South Platte River.

3.6.1.2 Contaminants are concentrated in irregular plumes primarily in the western flow path. Most of the contaminants are concentrated in the alluvial aquifer with lesser contaminant levels detected in the Denver Sands. Leakage from Basin F is one source of contaminants; however, basins C, D, and E, as well as pipelines and the sewage lagoon are additional suspected sources.

3.6.1.3 Surfacing of ground water is common in low spots, such as at the bog and along First Creek. Zones of impermeable clays and silts in the aquifer may slightly alter the flow or may form isolated perched water tables. The flow pattern is also locally modified by discharge from wells and recharge from injection wells, and seepage from ponds, lagoons, and canals. The seepage type of artificial recharge is the primary cause of the extensive contamination at RMA, the main sources being the disposal basins for process wastes. Only minor fluctuations in ground water level have been recorded over several years, indicating the relative stability of the ground water system. The ground water in the alluvial aquifer is mineralized and of poor quality, with an average total dissolved solids concentration of 1300 mg/liter. This water is marginally-suitable-to-unsuitable for domestic supplies, but is used where better quality water is not available.

3.6.2 The bedrock aquifers for the Denver Basin include, from oldest to youngest, the Fountain and Lyons Formations, the upper and lower parts of

he Dakota group, the Laramie-Fox Hills aquifer, the upper part of the Laramie Formation, and the Arapahoe, Denver, and Dawson Formations, which are the most commonly used in the RMA north boundary area. While the alluvial aquifer is recharged predominantly by the 11 to 17 inches of precipitation each year, the Denver Formation sandstones are recharged from the alluvial aquifer, with the gradients typically steepening at the points of decreased permeability in the sandstone. The sandstones of the Denver Formation in many cases are interconnected and have a much slower flow rate. Sandstones in the Denver Formation are commonly saturated and have an artesian head within a few feet of the piezometric surface in the alluvial aquifer. The quality of water from the bedrock aquifer is variable and locally may contain high concentrations of dissolved solids, iron, and hydrogen sulfide gas.

3.6.2.1 Well drillers familiar with the Denver Basin generally indicate that the shallower Denver Sands yield less water to wells than deeper Denver and Arapahoe sands, suggesting that sands are less permeable or less prevalent in the upper (250 feet) part of the section. This generalization could be true because of weathering as well as the presence of more coarse facies deeper in the section. The old erosional surface of the Denver Formation went through a long period of erosion and dessication during most of the Tertiary Period which could have resulted in reduction of permeabilities through chemical deterioration of sand grains.

3.6.2.2 Field permeability tests indicate hydraulic conductivities of up to 19 feet per year (1.9 x 10^{-5} cm/sec) in the fractured claystone or clay shale. This was the only test conducted specifically in this type of rock. However, two pump tests were performed, pumping from Denver Sand units and in both cases these sands were highly confined by the overlying claystone beds. A slight amount of leakance was detected in data for the test on Well 1041 which indicated a hydraulic conductivity of about 0.1 foot per year (1 x 10^{-7} cm/sec) for the confining layer. WES (1980) reports 23 slug tests in Denver Sand beds and in all but two tests, confined aquifer characteristics were reported.

3.6.2.3 Hydraulic conductivities of Denver Formation sandstones determined by WES slug tests ranged from about 14,000 feet per year (1.4×10^{-2} cm/sec) to 0.8 feet per year (8×10^{-7} cm/sec) which suggests extreme variations due to cementing, density, and gradation. However, the two pump tests (1041 and 1045) yielded relatively consistent results from two widely separated sands with hydraulic conductivities ranging from 405 feet per year (4.05×10^{-4} cm/sec) to 576 feet per year (5.76×10^{-4} cm/sec). The pump tests used observation wells for time drawdown measurements. The use of observation wells avoids effects due to well construction and is more reliable than in-well slug tests for determining hydraulic conductivity. Nevertheless, there is probably a considerable range in permeability in the Denver Formation sandstones especially in the thinner, siltier beds and cemented zones. The larger units are probably more permeable as well as more extensive laterally.

3.6.2.4 The variability of permeability within the Denver Formation presents some risks regarding interception of contaminants. However, the risks involved are considered to be low because: (1) total flow through this formation is relatively minor and slow; (2) contaminant levels are low; (3) much of the flow through the more permeable sand lenses can be intercepted by wells; and (4) fractures appear to be relatively tight. Contaminant plumes in the Denver Formation sandstones can be intercepted with wells by creating a pumping trough and inducing flow to the wells. If fractures are open and extensive enough to transmit significant quantities of water, it is reasonable then to assume that the fractures would drain into the sand lenses that are stressed by pumping. The primary risk for this type of system with highly variable permeabilities is in determining a suitable well spacing. However, the well system provides flexibility in that wells can be added as needed and/or pumping rates can be varied based on operational experience. If large open fractures were present at the base of the cutoff wall during construction, the bentonite slurry would tend to penetrate and seal them at least partially, if they were large enough to transmit

relatively large flows. Also, if open fractures are in direct hydraulic connection with the alluvial aquifer, alluvial dewatering wells will intercept at least part of these flows because about the same hydraulic stress inducing flow to the wells would be imposed on the fracture flow as on the alluvial aquifer. On the recharge side of the barrier, treated water mixes and dilutes contaminants bypassing the barrier through shallow fractures. Therefore, the risks involved due to the relative geologic complexities of the Denver Formation are minimal. The monitoring program should at least detect any serious problems that may develop. Also, ground water velocities are so slow in the Denver Formation that abundant time will be available to activate remedial actions if serious defects are detected.

3.6.2.5 Flow in the Denver Formation is in essentially the same direction as in the alluvial aquifer. Potentiometric levels are slightly lower overall, resulting in a downward component of flow. Gradients in the two units are generally parallel but may be slightly steeper at the NBE in the Denver Formation than in the alluvial aquifer, due to a regional flow net effect.

3.6.2.6 Contaminant levels within the Denver Formation are very low except for sands in direct contact with the alluvial aquifer. However, contaminants have been detected in various deeper Denver Sands. The low levels of contaminants that are present are the result of the slight downward flow component.

3.6.3 Regional studies of the ground waterflow system by Geraghty and Miller (Evaluations of the Hydrogeologic and Contamination Migration Patterns, Rocky Mountain Arsenal, Denver, Colorado, January 1981) indicate a general north to northwesterly flow angling toward the South Fork Platte River. The Denver Formation and the alluvial deposits interact in transmitting flows and are both part of the same flow system. Flow in the Denver Formation is both confined and unconfined and in the alluvium it is generally unconfined but may be locally semiconfined. Potentiometric levels in both units generally

correspond rather closely, with a tendency for levels in the Denver Formation to be slightly lower. Locally potentiometric levels between may vary greatly due to locally imposed stresses such as heavy pumping from one of the units or by local recharge. Even though flow through both geologic units is part of one system, there are significant differences that were used to advantage in developing pollution containment systems. In general, the alluvial aquifer is much more permeable than sands or other materials in the Denver Formation (by more than two orders of magnitude at the North Boundary). Where present, the alluvium transmits a much greater percentage of the flow and thus a greater portion of the contaminants as well. This is fortunate in that more options were available for intercepting this flow at generally less cost.

CHAPTER 4. - EXCAVATION PROCEDURES

4.1 GENERAL EXCAVATIONS. Standard excavation methods were used on structure excavations and trenches for utility lines, using backhoes and tracked dozers. Scrapers and graders were used to build roads and working surfaces, as well as for excavating the cut at the eastern end of the trench working surface. Equipment used on the project is listed in Table 4-1 and is shown in Photos 44 through 52.

TABLE 4-1

EQUIPMENT

MODEL NO.	TYPE
CAT. 166	Grader
CAT. 146	Grader
CAT. 623B	Scraper
CAT. G815	Sheepsfoot Compactor
CAT. D8K	Dozer
CAT. D6	Dozer
MF 55C	Front End Loader
Parsons 155L	Trencher
J. Deere 690B	Backhoe
IH 250-A	Dozer
IH TD-8-E	Dozer
Poclain 220	Backhoe
Ford 6500	Backhoe
Kelley K12	Reverse Rotary Drill
Port-A-Drill 522	Air-Foam Rotary Drill

4.2 SCHEDULING. The scheduling of work was critical to the maintenance of an uninterrupted flow of ground water in the north boundary. Originally it was intended that all dewater and recharge wells and the collection/distribution system piping be operational prior to slurry trench excavation. This was to prevent buildup of ground water up gradient of the barrier. The actual method used involved splitting the barrier into three phases: Phase I from station -8+60 to station 5+40, Phase II from station 20+40 to station 37+40, and Phase III from station 58+80 to station 37+40. Each phase would

have those dewater and recharge wells adjacent to it operational prior to slurry trench excavation, allowing concurrent trenching and well drilling in different phases. Phase I progressed from west to east to tie into the pilot system barrier. Phase II went from west to east, tying into the pilot system barrier and progressing to station 37+40. Phase III went from east to west, tying in at station 37+40 to complete the barrier.

4.3 **EXCAVATION GRADES.** Excavation was to the lines and grades as shown on plates 19 through 30. Some of the changes from the original design are discussed in the following sections.

4.3.1 The minimum excavation line for keying in the trench bottom is shown on Plates 19 through 30, with the material from that depth downward being inspected for suitable termination material by the field geologist. The termination depth was generally from 1 to 2 feet below the minimum excavation line, with some locations up to 9 feet below the minimum.

4.3.2 Of the 124 wells drilled on site, 42 wells had field adjustments from the design depth. Most of the adjustments were to raise or lower well screens for the best placement in sand or gravel zones.

4.3.3 To prevent the destruction of several Russian Olive trees along the proposed north perimeter road, the road was moved 50 feet to the south from station 82+00 to station 59+00. This did not affect any structural or mechanical portions of the project.

4.4 **DEWATERING PROVISIONS.** Project scheduling required that alluvial dewater and recharge wells be operational prior to the initiation of trenching in each of the three phases, primarily to lower the ground water to aid in trenching. RMA, under its own contracting authority for the treatment system, was to have the system ready for tie-in when the collection system was complete. Due to scheduling problems, the anticipated date for tie-in slipped to 15 August 1980, well after the barrier was scheduled for completion. Since untreated water could not properly be recharged into the aquifer

on the down gradient side of the barrier, a system of temporary piping and pumps was held in standby in case of serious surface flooding of ground water in areas where the barrier was complete. The untreated water from the alluvial dewater wells was to be pumped upgradient and dumped on the ground to recharge into the aquifer. The large storage capability in the aquifer and the excavation of the Phase III portion of the trench last, where the heaviest ground-water flow occurred, delayed the use of the temporary pumping system until it was no longer necessary. Some surface flooding and a rapid rise in ground water did occur in the lower areas during the last 2 weeks of slurry trench excavation, but it did not seriously affect construction. Subsequent pumping and treatment lowered the water level in the previously flooded areas.

4.5 <u>WELL DRILLING</u>. Several types of wells were drilled for the project, each type requiring a different design or drilling method. Typical well details are shown on Plates 77 and 78, and as-built data on wells are shown in Appendix C. The types of wells are alluvial dewater, alluvial recharge, Denver sandstone dewater, shallow monitor, and deep monitor. Material encountered during drilling of the wells was similar to the preconstruction borings, except that the claystone was generally deeper than anticipated, and the thicknesses and extent of the cemented zones were much larger than the borings indicated. The small-diameter borehole drilling equipment used in the preconstruction borings may have penetrated cemented zones and concentrations of cobbles more easily than the large bits used in well construction. Drilling of the dewater and recharge wells was more difficult than anticipated due to the cemented zones and large cobbles.

4.5.1 Reverse rotary drilling was used on the alluvial dewater and recharge wells, primarily to prevent clogging of the alluvial aquifer with drilling fluids under high pressure. The setup for this method is shown on Photo No. 13. The reverse rotary worked quite well except in heavily cemented alluvium, where drilling rates were reduced significantly, and in zones of large cobbles, where the valves and piping tended to trap larger objects, as in Photo 29. A rock bailer was used to pull loose cobbles and boulders from the well borings to reduce down time for rock removal.

4.5.2 Denver sand dewatering wells were drilled first with the rotary method using bentonite drilling fluid into the Denver Formation. Below that depth, the wells were drilled using air rotary with the addition of foam as necessary. This procedure was effective in drilling the wells and was used to minimize contamination and clogging of the sandstone aquifer. This method does not provide samples suitable for proper logging of the hole, so geophysical logs were used to more accurately determine proper screen placement.

4.5.3 Shallow monitor wells were drilled using the same reverse rotary method used for alluvial dewater and recharge wells, except that test holes were drilled at each location first, using mud rotary methods. If suitable aquifer zones were located, the smaller 8-inch diameter test holes were used as pilots for the larger 16 to 18-inch well holes.

4.5.4 Deep monitor wells were drilled using a combination of mud rotary, and air or foam rotary methods, similar to those used on Denver sand dewater wells. Test holes were drilled using mud or air rotary to locate deep sandstones. These test holes were then used as pilot holes for the larger well holes if suitable zones were found.

4.6 BARRIER CONSTRUCTION. The working surface for the barrier was made by standard cut and fill methods, using scrapers, graders, and dozers. Vegetation including tree stumps, grass, and brush was stripped to prevent possible inclusion in the trench. The surface was prepared by leveling it as much as possible to prevent the slurry from running out the low ends of the trench. From station 42+00 to First Creek, the existing soil was saturated, requiring several layers of compacted fill to create a stable platform. The working surface was designed to contain excavated material and slurry, provide a mixing area for backfill, and conserve slurry by allowing a flow back into the trench. Photo No. 39 shows the basic setup with mixing areas on the north and slurry supply piping on the south of the trench centerline.

4.6.1 After preparation of the working surface, the slurry was mixed in the slurry pond area shown in Photos Nos. 32, 33, and 34. The dry sodium

bentonite was supplied from high pressure bulk tank trucks in 25 to 29-ton loads, and mixed with treated water by a venturi system and a diesel powered pump. After testing as described in Chapter 2, the slurry was held in storage ponds. When trench excavation required the addition of slurry, it was pumped from the storage ponds to the trench by the use of a centrifugal pump and a 6-inch temporary piping system, which paralleled the trench working surface. The supply pipe could be extended or shortened quite rapidly if required as backfilling progressed. As the slurry trench became deeper and slurry was removed with the overburden, the slurry level dropped. Additional slurry was added to maintain the level within 1 to 2 feet of the working surface. Slurry not meeting specifications during excavation was pumped out, along with any bottom sediments, or blended with fresh slurry in the trench until it was suitable.

4.6.2 Trench Excavation. The slurry trench was excavated with an FMC Link Belt 7400 backhoe with an extension on the boom to allow it to extend to a depth of 45 feet, as shown in Photo No. 44. During the last month of trench excavation, depths required to reach sound material were below 45 feet, so a 1066 Koehring backhoe with a one-piece extension arm was used. This new backhoe with extension had a reach of 50 to 55 feet in depth, and had less down time attributable to extension arm problems. The bucket used in Phase I was non-perforated, except for two holes that allowed the release of a vacuum formed by the wet overburden. In Phases II and III, the hard materials in the cemented alluvium and Denver Formation sandstones were more difficult to excavate, requiring the use of the permafrost bucket shown in Photo No. 47. A smaller version of the non-perforated bucket was used on the Koehring backhoe from stations 38+05 to 40+00. Initial excavation was started outside the plan starting point and sloped down to full depth at the starting point. This allowed a sloped surface for backfill to slide on, and eliminated the need for a clamshell for initial backfill placement. Slurry was placed in the trench at that point and maintained within 2 feet of the working surface by adding slurry as the excavation progressed. Samples and inspection as described in Chapter 2 were used to determine the depth of termination.

4.6.3 Trench Backfill. Excavated material and slurry from the trench was placed on the north side of the working surface at an adequate distance from the trench to prevent instability. Material unsuitable for backfill was placed separately by the backhoe. Very little select outside material was brought in, and no on-site borrow was used to meet gradation requirements. A 1- to 2-foot dike was formed along the trench to prevent unblended material from flowing in. The excavated material was mixed with slurry by tracking and blading with dozers, and was then tested as described in Chapter 2. More slurry or select material was blended with inadequate backfill mixture to meet requirements. Mixed and blended backfill was then pushed from the working surface to the trench, allowing it to slide down the inclined surface of previously placed backfill. If necessary, the backfill was rodded along the sliding surface to remove pockets of slurry. No pushing of backfill directly over the trench edge was allowed. Backfilling always followed the trench excavation by 30 to 100 feet. At the end of each shift, the backfill profile was sounded, and then once again in the morning prior to backfilling, to determine overnight sliding and settlements. After the trench backfill reached the working surface, at least 1 to 2 days was allowed for settlement to occur. The backfill was then capped by 1 to 2 feet of impermeable fill to complete the barrier. No settlements occurred in the completed barrier during construction.

4.7 BLASTING. Deep portions of the Denver Formation sandstones from station 38+05 to station 40+00 were very difficult to excavate due to the hardness of the material, the depth of the material, and the limitations of the excavating equipment. ECI hired Western Blasting Contractors, Inc., to fracture the hard zones prior to and during trenching operations in the area so that excavation would be easier. RMA requested a non-electric system for blasting, so HD primadet caps and primacord were used to detonate patterns of 2-1/2" x 16" Hercules unigel. Several separate blasts were conducted along the trench. The first five blasts used patterns of holes lined with 3-inch thinwall PVC and stemmed with ±25 feet of 3/4-inch rock. Blasts patterns four and five overlapped previous blasts in order to fracture the sandstones to deeper depths. Blasts six through eight were placed through the slurry in a string directly on the rock surface. No adverse effects on the trench walls or bottom areas were observed after blasting.

TABLE 4-2

BLASTING RECORD

Date	# Holes	Spacing, Ft	Load Depth, Ft	Powder Per Hole, Lbs	Stationing of Blast
13 July	13	5	25-33	20	38+25-38+90
15 July	20	5	25-35	23.3	38+90-39+90
17 July	13	5	25-34	21	39+90-40+55
27 July	25	4.3	29-37	33	38+22-39+80
28 July	30	4.3	28-38.5	40	39+80-40+60
11 Aug	(trench)	---	29-32	72	38+10-38+25
11 Aug	(trench)	---	29-32	43	38+10-38+25
11 Aug	(trench)	---	29-32	86	38+10-38+25

4.8 **SAFETY PRECAUTIONS.** Standard safety procedures were used, as prescribed in the Corps of Engineers Safety and Health Requirements Manual, EM 385-1-1, dated 1 June 1977. Due to the nature of contaminants at the project, bottled drinking water was used onsite, and rubber boots and gloves were made available to those working in wet areas. No other protection was considered necessary. When blasting was performed, RMA Security was notified of each imminent blast. No explosive materials were stored onsite.

CHAPTER 5. - CHARACTER OF FOUNDATION

5.1 GENERAL CONDITIONS. General discussions of the conditions encountered during construction excavation are described in Chapter 3. Most of the solid and bedrock conditions encountered were as expected from the preconstruction borings shown on plates 19 through 40. The locations of cemented alluvium (Plates 19 through 30), cobble concentrations, hard Denver sandstone, and claystone weathering that caused difficult trenching and well drilling conditions will be discussed here.

5.2 CEMENTED ZONES. Cemented zones were encountered in both well drilling and trench excavation operations. The cemented zones contained fine sand to cobble sized particles cemented with calcium carbonate. The hardness of the cemented zones varied, with the hardest material generally being deeper and in a saturated environment. The thickness varied from 1 to 13 feet in discontinuous zones, as shown on Plate 24, with depth varying from 10 feet to 24 feet.

5.2.1 Cemented alluvium was encountered during the drilling of the dewater wells in wells DW-7 through DW-16. This zone varied in thickness from 4 to 11 feet.

5.2.2 During drilling of the recharge wells, the cemented alluvium was encountered in wells RW-7 through RW-13. This zone varied in thickness from 1 to 6 feet.

5.2.3 During the slurry trench excavation, cemented material was encountered discontinuously between Station 20+50 and Station 31+00. The thickness varied from 1 to 13 feet at depths between 12 and 20 feet. The thickest zone, 13 feet thick, was located between Station 29+60 and Station 29+80, at depths of 10 to 23 feet. The cemented zone became discontinuous between Station 25+90 and Station 26+60, with a thickness of 1 to 2 feet where encountered.

5.3 **COBBLES AND BOULDERS.** Cobbles and small boulders were encountered in the alluvium throughout the project site. These did not cause any difficulty in excavating the slurry trench. They did, however, cause some delay in drilling operations, especially with the reverse rotary methods. The larger cobbles and boulders tended to lodge in the bit intake as shown in photo 29 in the return valve, or in the Kelley. A concentration of cobbles and boulders was found in the alluvium in the bedrock low area between Station 40+00 and Station 51+00, from depths of 10 feet to 30 feet.

5.4 **DENVER FORMATION SANDSTONES.** The blue-gray sandstones of the Denver Formation were occasionally encountered during well drilling and trench excavating. The sandstone ranged from medium to very hard. A yellow-brown weathered sandstone zone was frequently found at the base of the blue-gray sandstone. The yellow-brown zone ranged in thickness from 1 to 3 feet. The total sandstone thickness ranged from 1 to 12 feet, at depths from 22 to 40 feet.

5.4.1 Lignite coal in very thin seams was encountered in the sandstones between Station 37+70 and Station 40+50. The trench was keyed through these seams to prevent the lateral flow of ground water under the barrier.

5.4.2 The thickest zone of Denver Formation sandstone was encountered in the trench between Station 37+90 and Station 41+10. This was also the hardest material encountered, where blasting was required to fracture the rock for easier removal with the backhoe.

5.5 **WEATHERED CLAYSTONE.** The upper surface of the claystone beneath the alluvium was weathered to depths of 5 feet. The contact with unweathered to slightly weathered claystone was gradational in some areas and distinct in others. The color of unweathered claystone was typically blue-gray while the weathered material varied from brown to gray. The only area containing significant amounts of fractured and weathered claystone was in the Phase 1 portion of the trench, where it extended 2 to 3 feet into the claystone, to depths of 30 feet.

CHAPTER 6. - PROJECT MODIFICATIONS AND CHANGES

6.1 Several modifications and changes were made from the original plans and specifications to improve the performance of the system, facilitate construction operations, or correct oversights. Those dealing primarily with foundation conditions or hydrology will be discussed.

6.2 MODIFICATIONS. A total of 12 modifications to the contract (see Table 6-1), were made during construction. Modifications 5, 7, and 9 deal only with payment procedures, and will not be discussed.

6.2.1 Modification 1 dealt primarily with redesigning the slope of the working surface. Original plans had steeper slopes than would be possible without allowing slurry to run out of the trench. Modification leveled the working surface considerably, allowing longer stretches of trench to be excavated with fewer delays, especially in the area from Station 54+40 to Station 58+80.

6.2.2 Modification 2 dealt primarily with pumps and control cables, and will not be discussed. Modification 3 allowed the contractor to split the barrier into 3 phases, as described in Chapter 4, to schedule work more effectively and avoid untimely work stoppages.

6.2.3 Modification 4 outlined the procedure for grout sealing piezometers in the slurry trench excavation areas. The piezometers were grouted to prevent them from contributing to fluid communication between aquifers in case they were damaged or destroyed during construction. Abandoned piezometers were pressure grouted with a cement-bentonite grout and allowed to stand for 24 hours before being disturbed by surface grading or trenching equipment.

6.2.4 Modification 6 dealt with the requirement for additional pipe sleeves in the wet well and the building addition, and supply lines between them.

TABLE 6-1

CONTRACT MODIFICATIONS

Mod.	Description	Cost
P00001	Revise trench configuration, and provide erosion control blankets	+ $9,000.00
P00002	Revise turbine pumps and well control cable	- $13,731.40
P00003	Revise contract specs. for well construction and barrier, and for solenoid valve material	No Cost
P00004	Grout abandoned wells	+ $6,587.00
P00005	Advance payment	No Cost
P00006	Revise piping in Building 808	+ $4,152.00
P00007	Revise slurry trench payment	No Cost
P00008	Dewater wet well	+ $8,298.00
P00009	Delete Mod P00005	No Cost
P000010	Pump schedule change, provide grounding conductors	+ $2,381.00
P000011	Abandon and drill new wells, pump electrical changes	+ $128,537.00
P000012	Revise pumps	+ $86,463.00
	Total Mod Costs	$213,686.60
	Contract Cost	$4,100,000.00
	Total Cost	$4,313,686.60

6.2.5 Modification 8 added special provisions for the temporary dewatering system described in Chapter 4. This temporary pumping system was for standby operation if high water levels required its use, and was kept available during construction of the treatment system. It was never used due to the slow water level rise.

6.2.6 Modification 10 adjusted pump placement in nine Denver sandstone dewatering wells. These wells were drilled deeper than plan depths to locate a suitable sandstone zone.

6.2.7 Modification 11 changed the motor voltage on some pumps, provided for different pumps in Denver sandstone dewater wells, and directed the replacement of the six original pilot system dewater wells. After several Denver sandstone dewater wells were drilled and the casing and screens were placed, it was found that the specified pumps would not fit in the casing. The original pumps were to be replaced with smaller diameter pumps with a special corrosion-resistant coating. During renovation of the pilot system wellhouses, it was found that the original galvanized steel screens in the dewater wells had failed, allowing gravel pack material to enter the wells. These six wells, DW-1 through DW-6, were grouted in, cut off, and abandoned. New wells with stainless steel screens, traps, risers, and pumps which met the more stringent requirements of this contract were drilled adjacent to the old ones.

6.2.8 Several additions to the control system were made by Modification 12 to alleviate unforeseen problems in the dewater system's switches and flow pattern. Also, it specified changes in the recharge well heads, requiring constant flow orifice valves to restrict pressure into the wells and strainers above the valves to prevent debris blockage in the solenoids.

6.3 CHANGES. The subcontractor performing trench backfill changed the procedure used for gradation testing of backfill after the initial inspection of the testing facilities. This was done without the consent or knowledge of

the Government, and was discovered late in the project. Subsequent testing revealed that the backfill gradation for much of the barrier was significantly out of the range specified in the contract. Permeability tests were performed on representative samples from the barrier. Laboratory permeabilities ranged from 10^{-7} cm/sec to 10^{-9} cm/sec.

CHAPTER 7. - POSSIBLE FUTURE PROBLEMS

7.1 **POTENTIAL PROBLEM CONDITIONS.** Several conditions are possible that could produce problems with the effectiveness of the containment/treatment system. Asioe from the possible failure of the mechanical portion of the system, which is beyond the scope of this report, possible problems could occur as described below.

7.1.1 "Windows" in the slurry trench backfill could allow contaminants in ground water to seep through at high ground water level periods. "Windowing" could occur by placing large particles of unblended backfill material, improper gradations of backfill, improper placement methods, or by sloughing of portions of the trench sides during excavation. Any of these could allow a higher permeability zone through the trench, and would be difficult to locate upon completion of construction.

7.1.2 Seepage through permeable zones in the Denver Formation below the depth of the slurry trench could allow movement of contaminants below the containment system. The system is designed and constructed to cut off known permeable zones in bedrock but, because of the heterogeneity of the Denver Formation, unknown permeable zones may exist.

7.1.3 Unexpected high ground-water levels could overtax the dewater/recharge system. This is unlikely under the range of expected situations for which the system was designed. The possibility for such an occurrence does exist, however, especially under a combination of conditions such as a high ground water level and heavy precipitation combined with a prolonged shutdown of the system, where ground water could build up along the barrier until the system is again operational (see Figure 7-1). There is an underground storage potential in the case of short term treatment system shutdowns. Approximately 400,000 gallons or two days of normal expected flow (135 gpm) could be stored before adverse buildups of ground water would begin.

MODEL SIMULATION RESULT
FLOODING DUE TO PUMP SYSTEM FAILURE

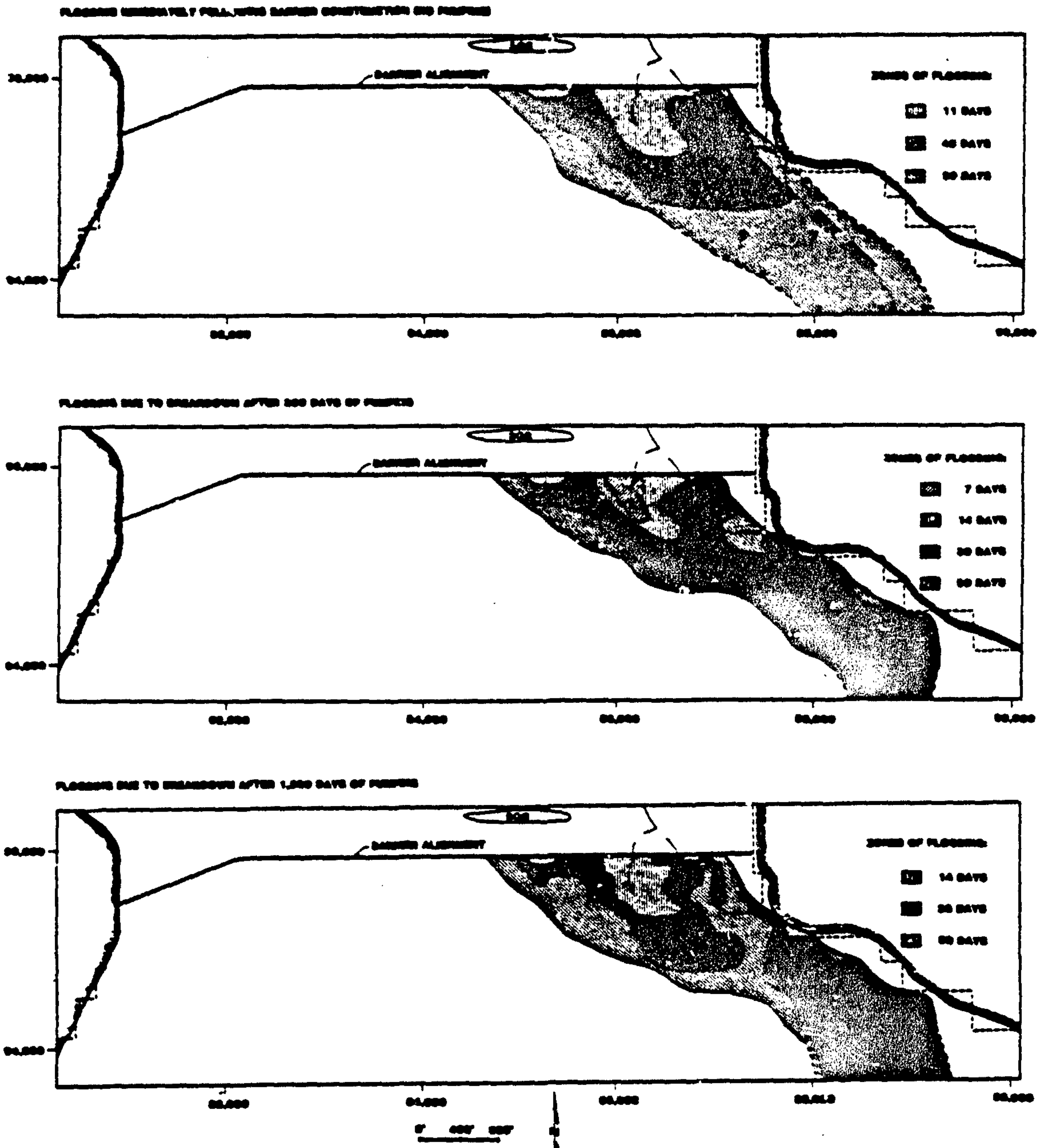


Figure 7-1

7.1.4 The system depends upon the proper functioning of the dewater and recharge wells. Nearly all wells require routine maintenance. Screens of pumped wells frequently become encrusted and lose efficiency. Recharge wells are susceptible to screen clogging without close control over the quality of the injection water.

7.2 <u>RECOMMENDED OBSERVATIONS</u>. The barrier and well system as designed will require periodic maintenance, as indicated by monitoring. Constant observation is recommended as follows:

7.2.1 Readings in the off-post monitoring wells should indicate the total effectiveness of the system, and would provide indications of problem areas of the barrier. Regular monitoring is essential.

7.2.2 Monitoring of wells and piezometers on the upgradient side of the system is also essential. Readings here could provide information on pretreatment contaminant levels and possibly on migrating ground water patterns as well. The careful monitoring of all water levels before and after construction would provide an early warning system for "mounding" of the ground water behind the barrier. A rise in the ground water could provide the necessary head for the water to seek an alternative route under the barrier by way of the Denver Formation sandstones or fractured clay-shale. Additional monitoring wells could be installed as required to detect any change in shape or depth of the contamination plumes.

7.2.3 Regular inspection of the surface of the slurry wall is recommended. Slumps or depressions along the surface of the barrier may be an indication of a "window" condition caused by improper backfill. Saturated surface conditions might indicate ineffective dewater/rewater system function. Such inspections might also reveal altered surface flow patterns after heavy rains, unauthorized excavations, vehicle traffic in unauthorized areas of the barrier, and many other conditions deleterious to the entire system. The well houses should be periodically inspected for water leaks, settlement, rodent damage, or debris accumulation, and should be kept under continued maintenance.

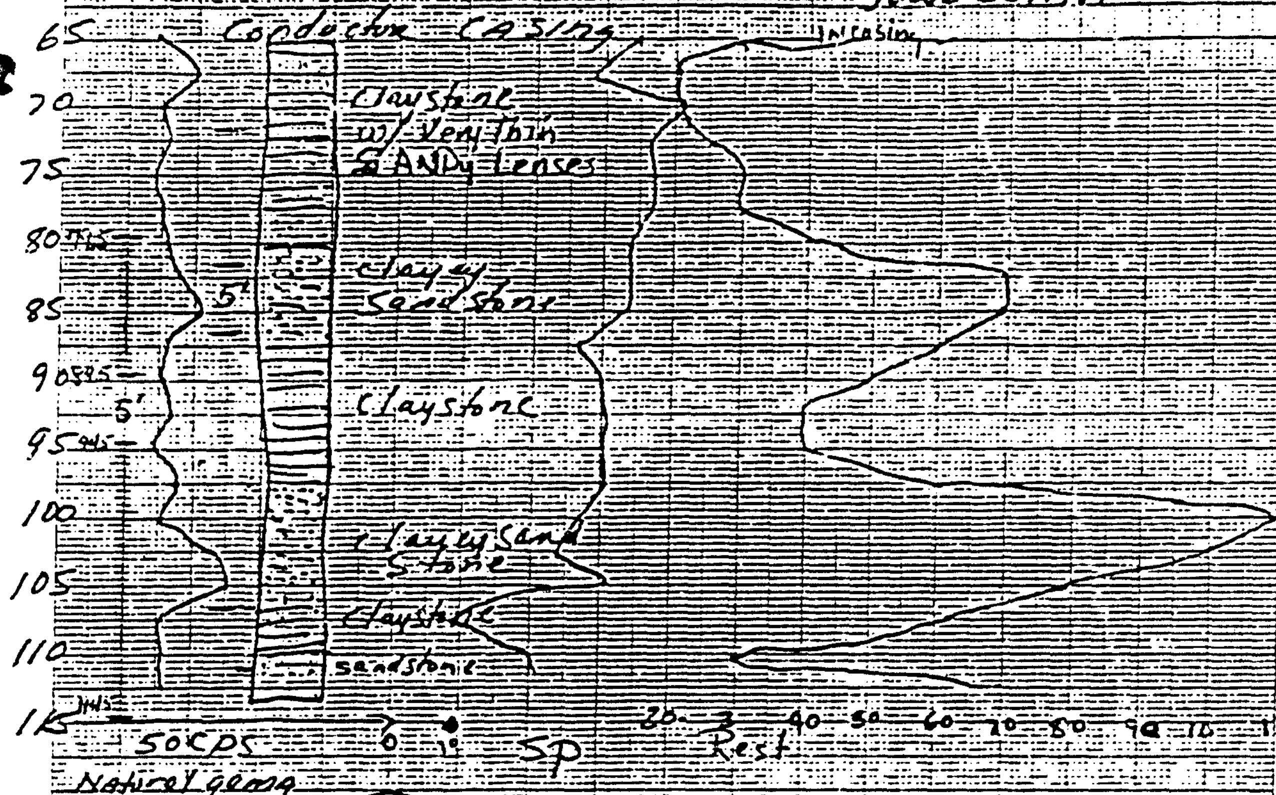
7.2.4 The continued effective functioning of the treatment portion of the system is critical to the maintenance of the containment portion. As noted previously, buildup of water on the upstream side will occur with a shutdown of the treatment system. Short shutdowns for maintenance are expected and designed into the system, but prolonged shutdown is not recommended. Pumping of untreated or poorly treated water into the rewater system could cause rapid deterioration or clogging of the well screens, reducing the system's effectiveness. The effectiveness of the treatment system should be monitored closely to catch developing problems before extensive system shutdowns are required.

7.2.5 ump control probe levels may eventually require adjustment to perform more efficiently. Pumping rates, water levels, and duration of pumping should be monitored for efficient performance.

APPENDIX A

Denver Formation Sandstone
Dewatering Well Electric Logs
DW-36 through DW-54

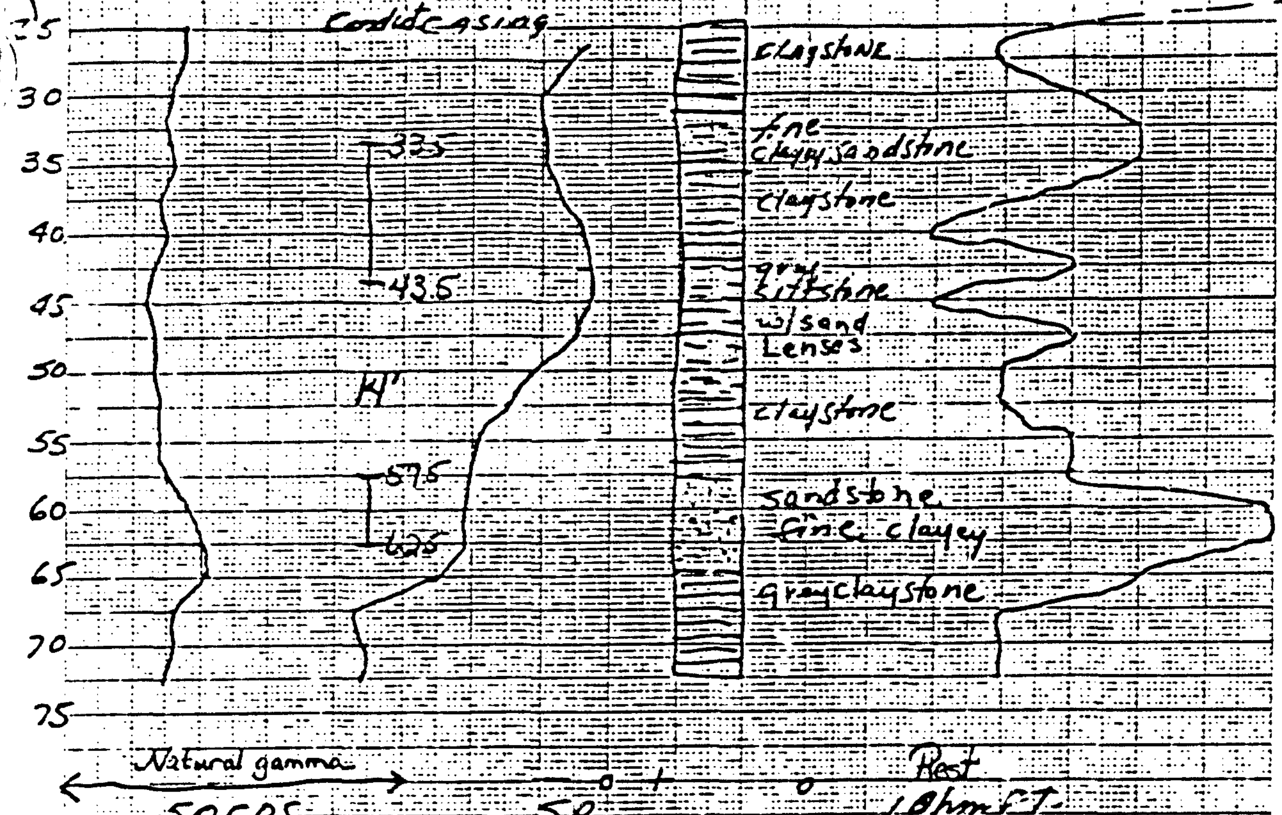
DW-36 Logged By K.L. Bechtold
June 25, 1981



Screen #1 79.5 - 84.5
Screen #2 94.5 - 114.5
Total depth 119.5
CL Smith
11:00 [illegible]

Received 2^30 pm 6/26/81
CJSmith

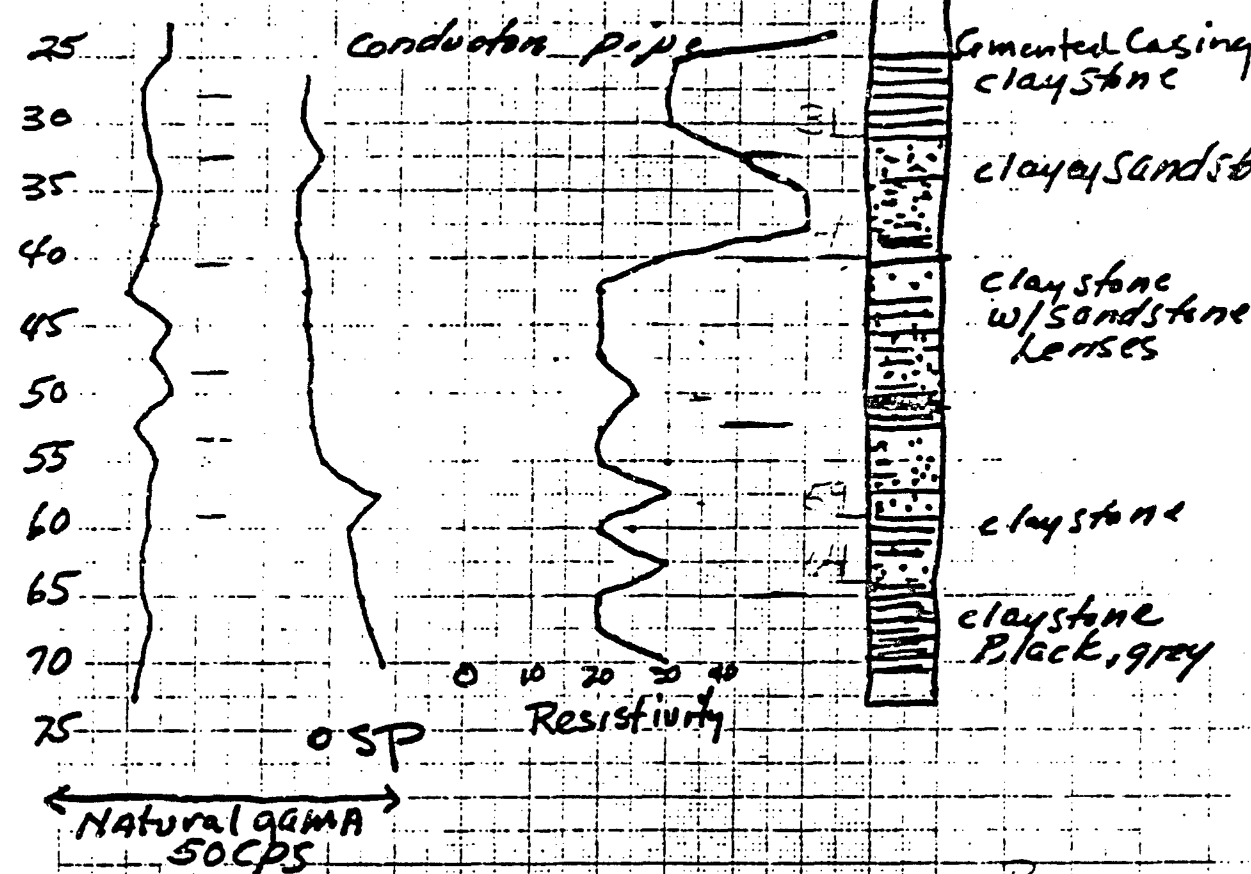
DW-37 Logged By KL Bechtold
June 26, 1981



1st Screen 33.5-43.5
2nd Screen 57.5-62.5
Total Depth 67.5
CJSmith
6/29/81
7:00 am

DW-38

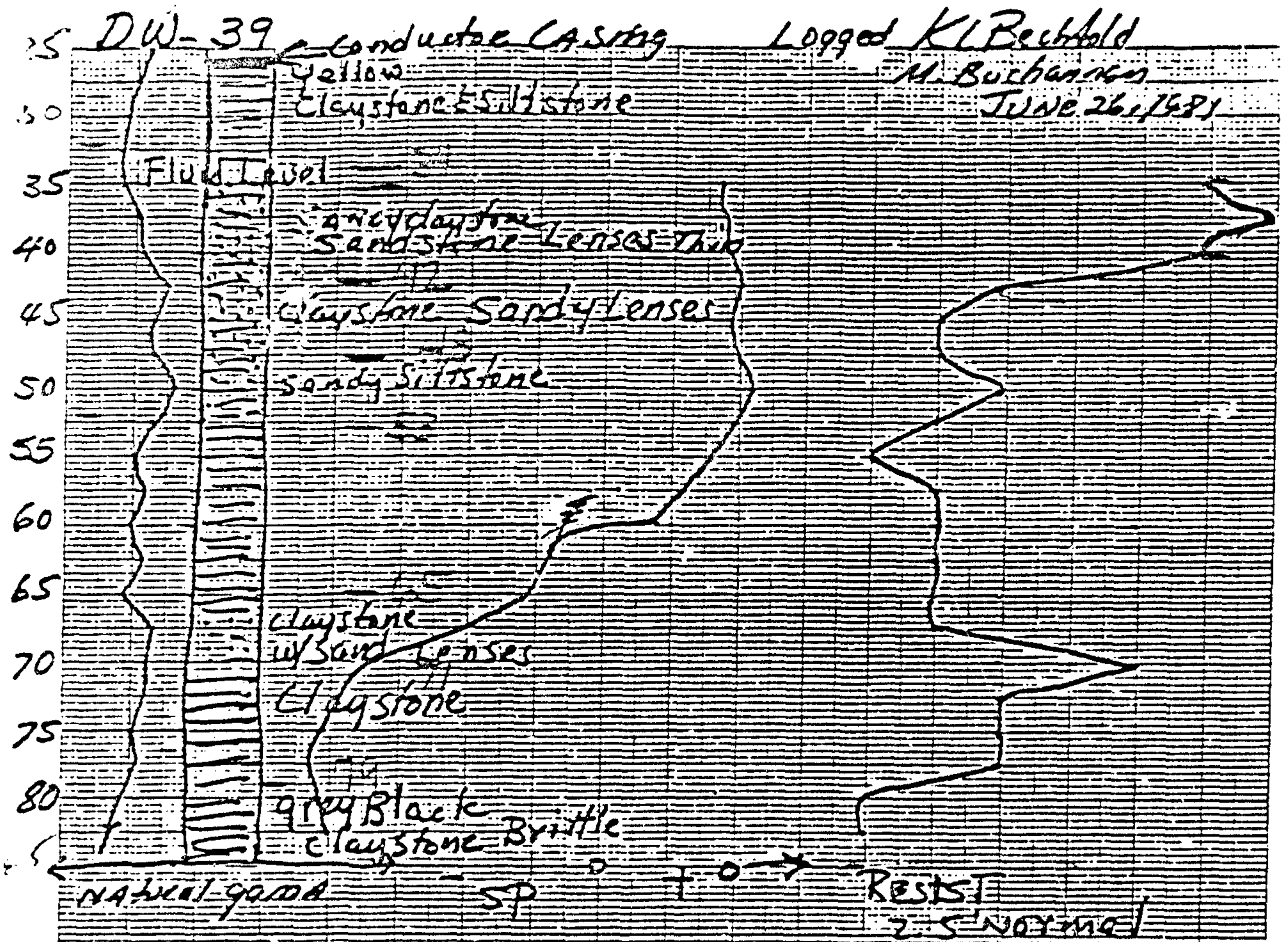
Logged KLBechtold
June 27, 1981



Rec'd 3:45
6-29-81

Set Screens
Per Contract Dwgs
4:00
6/29/81

60.9' depth
27.9'-42.9' screens
50.9'-55.9'



[illegible]
[illegible] 6/30
3:05 a.m.

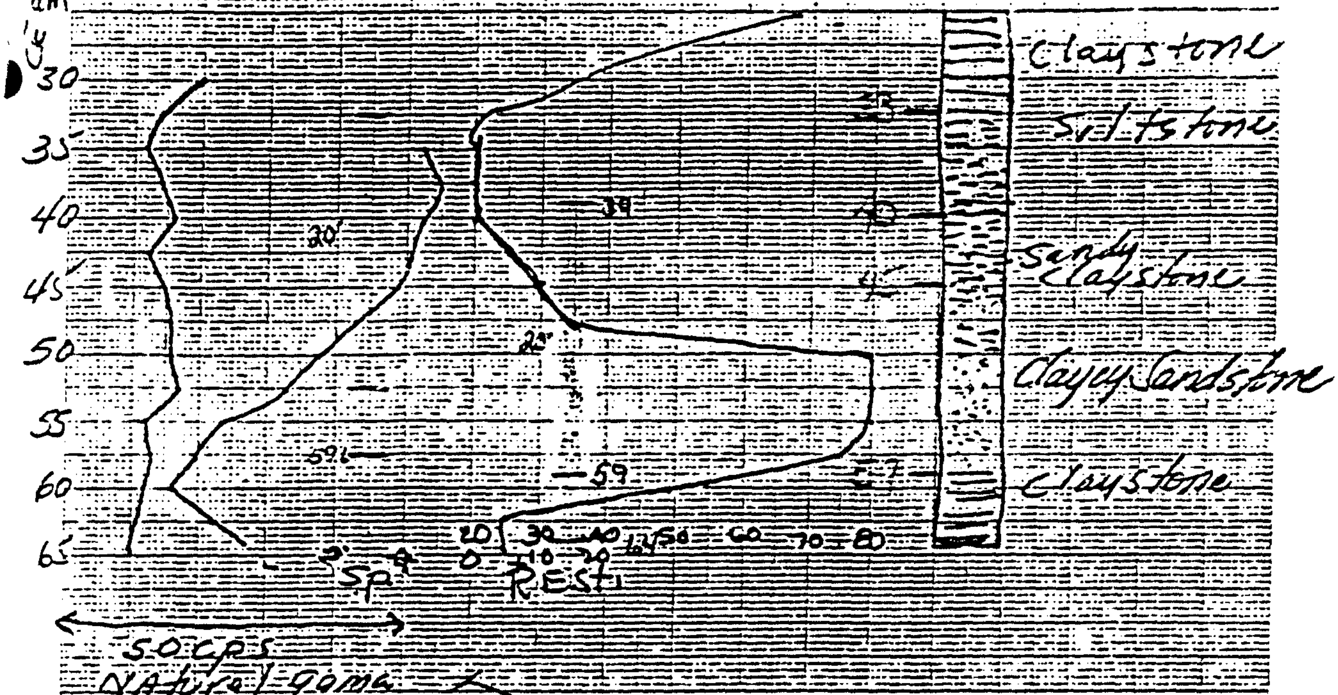
[illegible] 6/29
10:28 a.m.

Total Depth 56.0'
screen 31'-51'

Rec'd 7/6/81 Cindy

DW-40

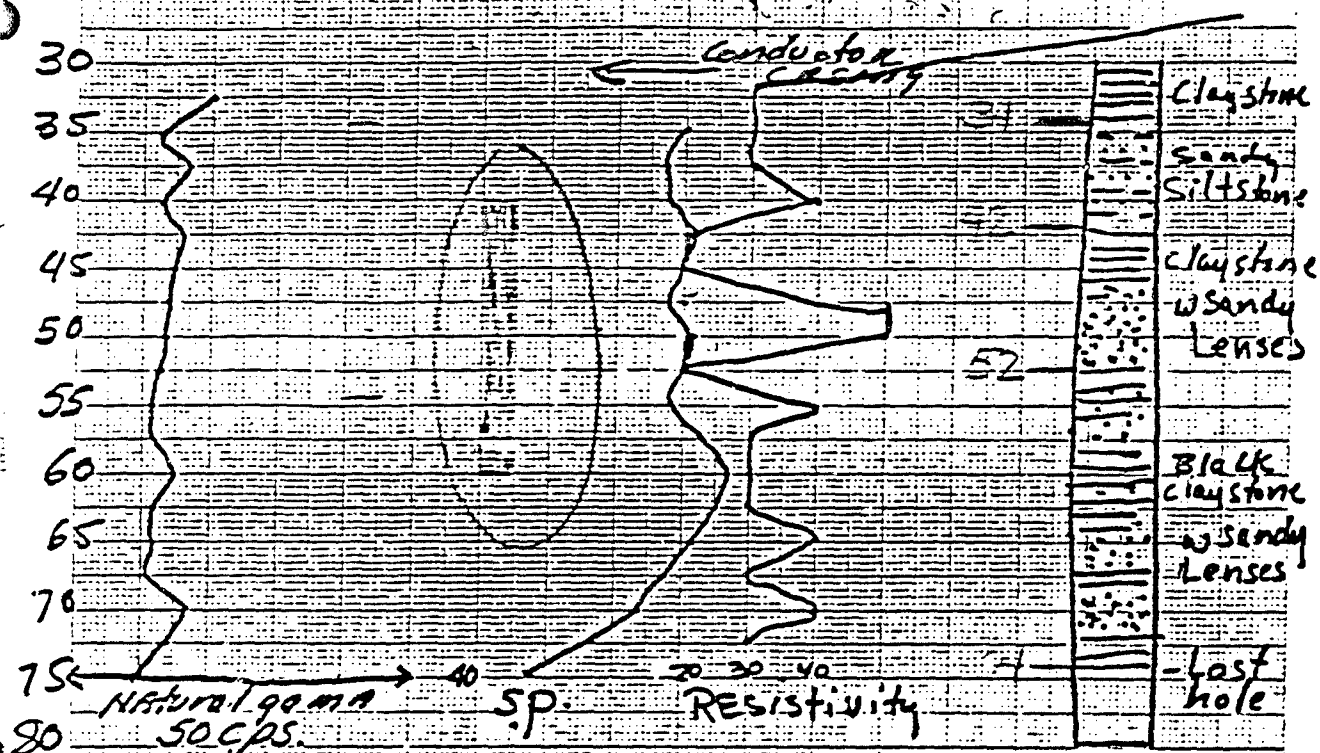
Logged July 3, 1981
By K. L. Bechtold



Set screen 39' - 59'
Total depth 64'
7/6/81
Cindy
1:30pm

DW-41

Logged KL Bechtold
June 27, 1981



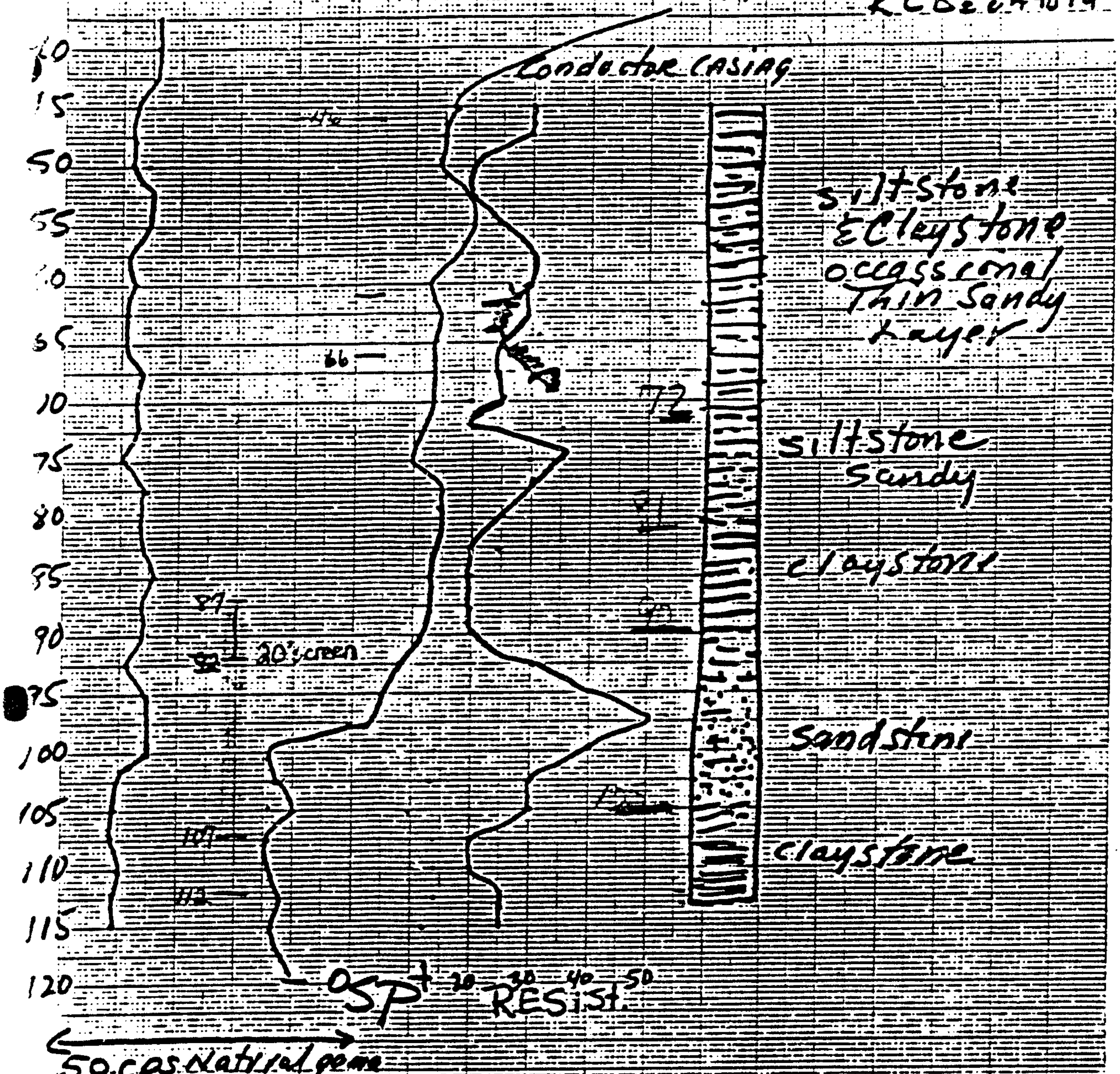
Set Top of Screen
@ 40' Bottom @ 60'
6-30-81
2:00 PM.

Drill 5:45
6/29/81

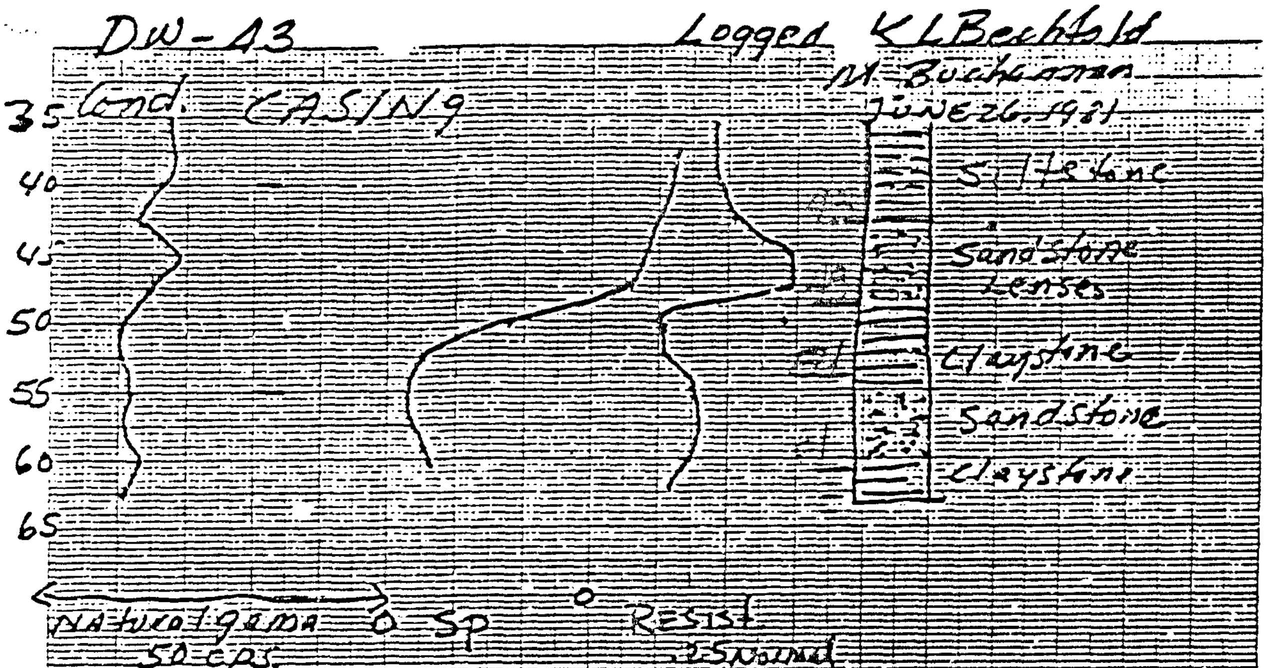
Rec'd 12:30 am 7/1/81
C. Smith

DW-42

Logged June 30, 1981
R L Bechtold



Set screen at
87-92' - 107'
Total depth of well 112'
Gw
2:00 am
7/1/81



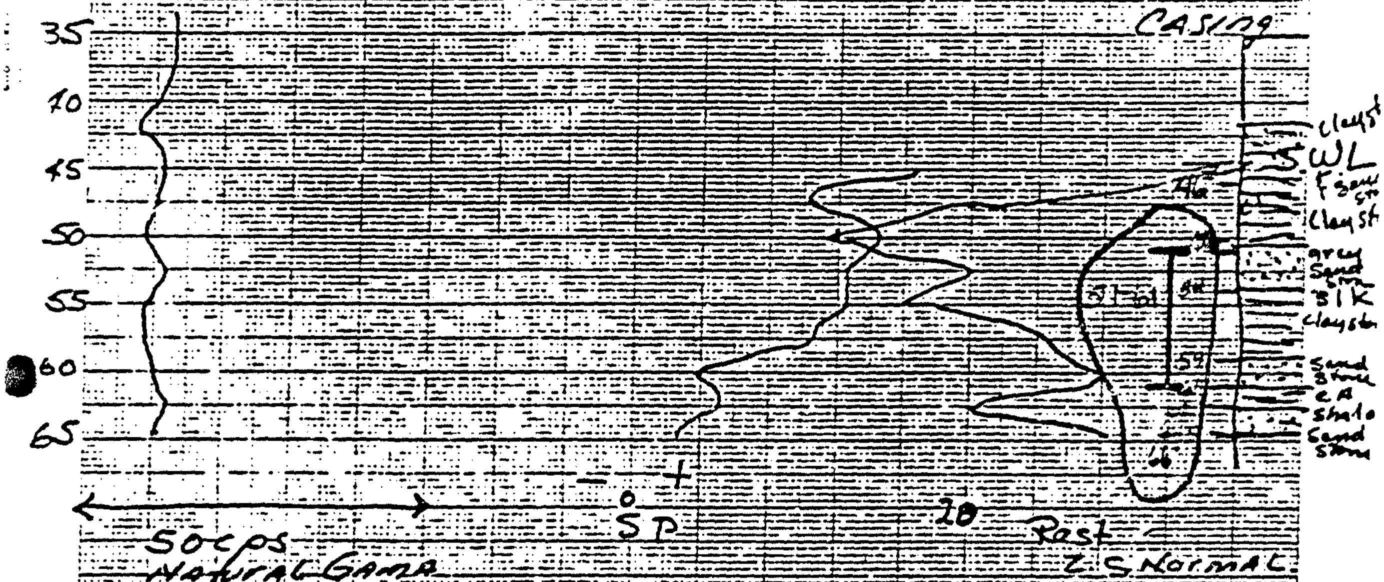
[illegible] Screen for [illegible] Done.
6-30-81
2:00 PM.

57' Depth
38'-57' Screen

Screen set 5_-6_
Total depth of well 66'

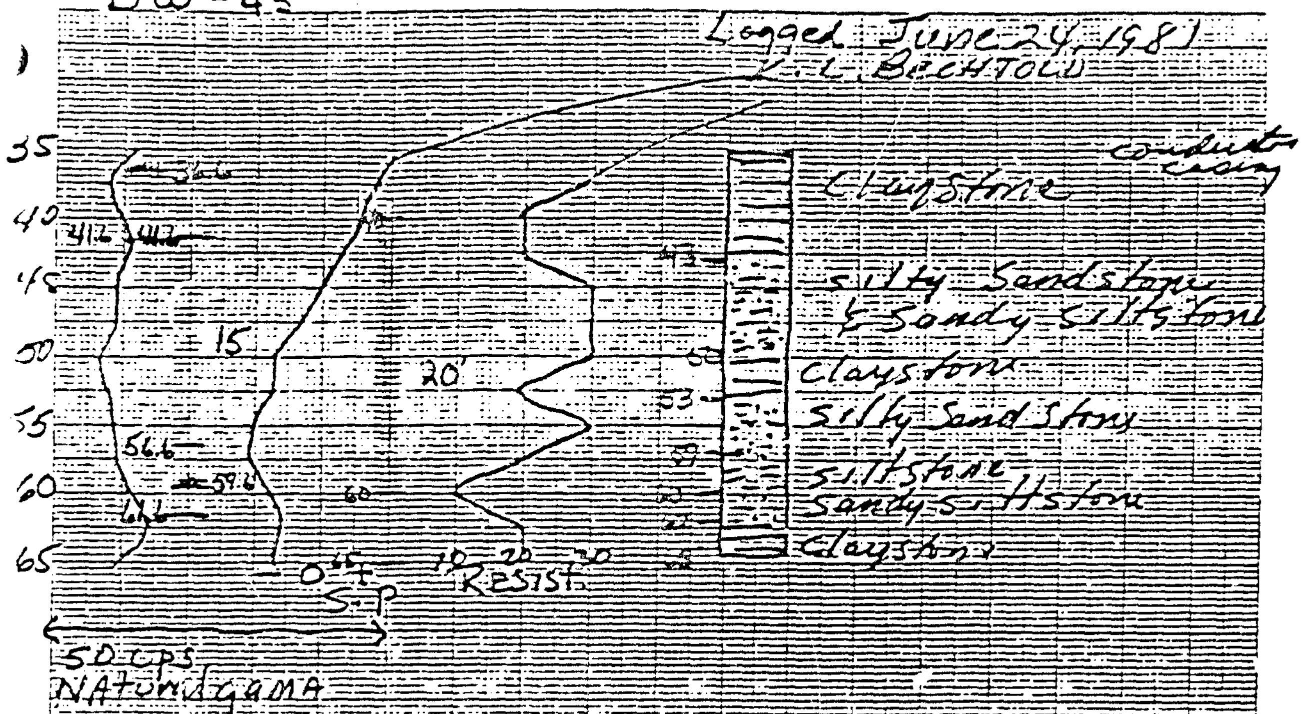
Electric Logs DW-44

By K L Bechtold June 24, 1981



Background 12 on ground

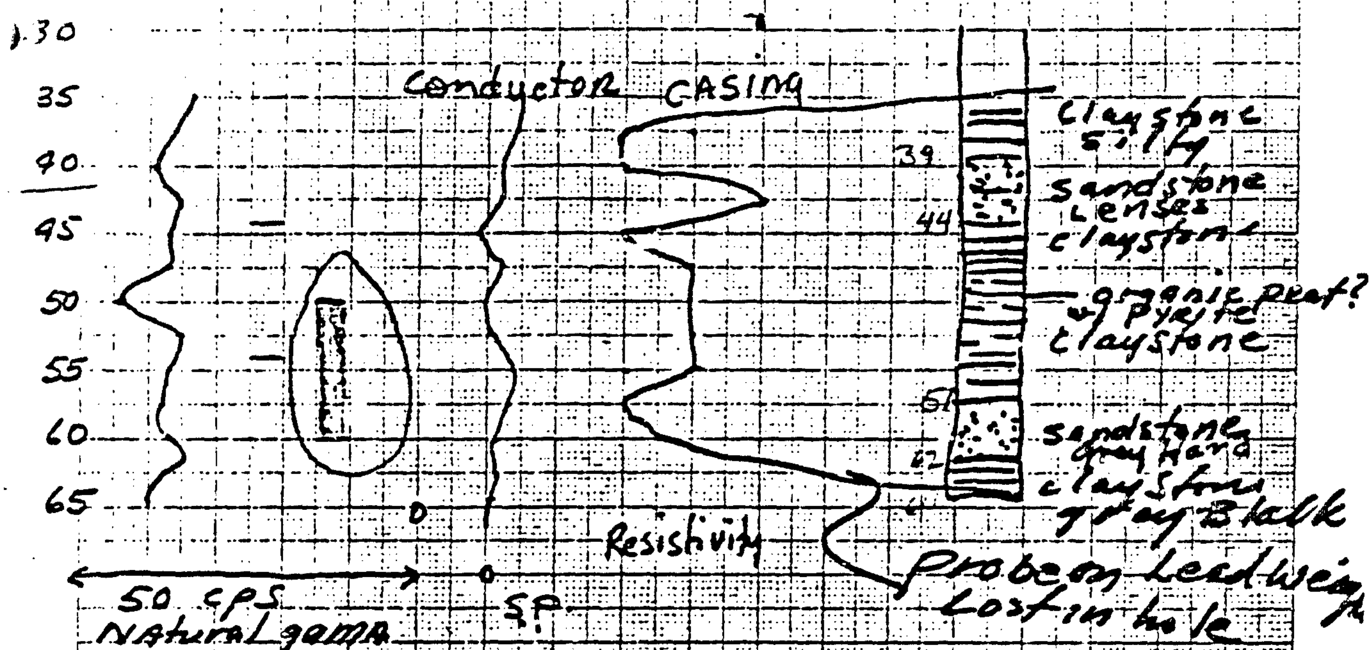
Rec'd 7/3/81
10:30 am Cindy
DW-45



Set screen 40'-60'
Total Depth 65'
7-3-81
11:30 am
Cindy

Pump setting
59.6' as per drawings
Probe setting as per drawings

DW-46 Logged By K. L Bechtold



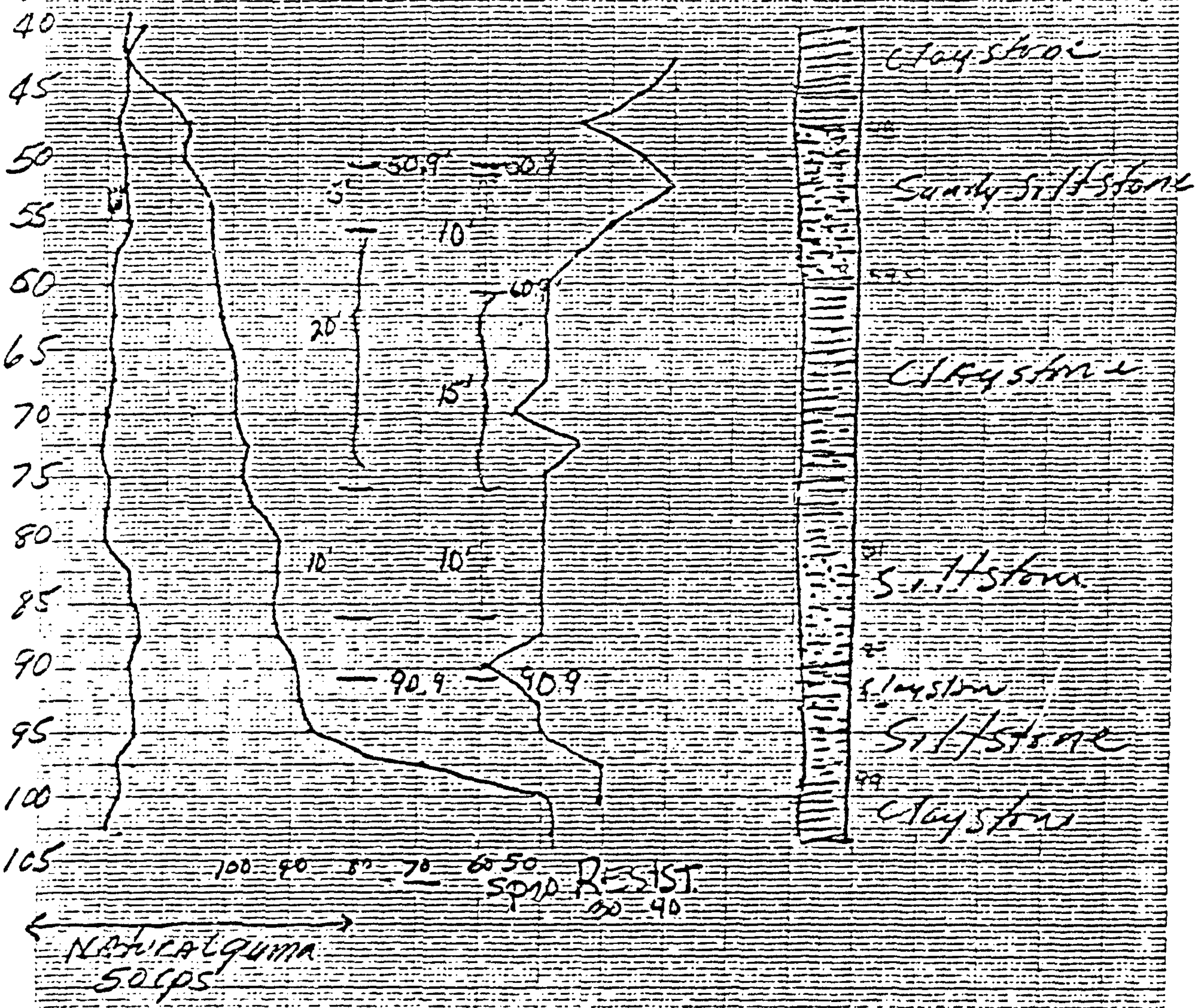
SAT Top of
Screen @ 50'
Bottom @ 60'
[illegible]
6-30-81
2:00 PM

Rec'd 3:45
6/29/81
[illegible]

Rec'd
7-?-81
10:00am
Andy

DW 47

Logged July 3, 1981
By K L Bechtold



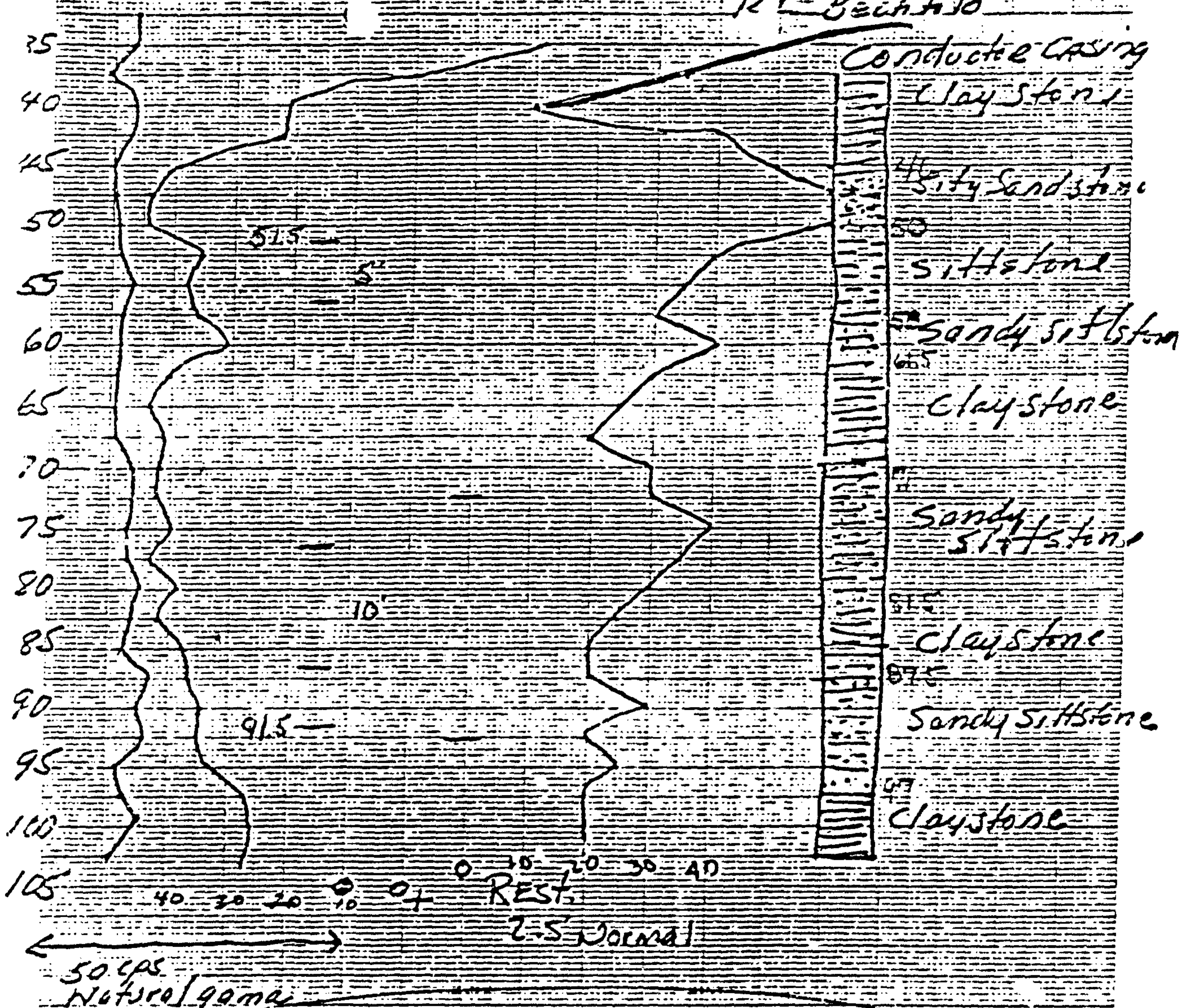
1st Screen change to 10' screen at contractor's option

Quantity for screen payment - 15'

Total depth same as contract drawings

Andy
2:00pm 7/6/81

DW-48 Logged July 2, 1981
K. Bechtold

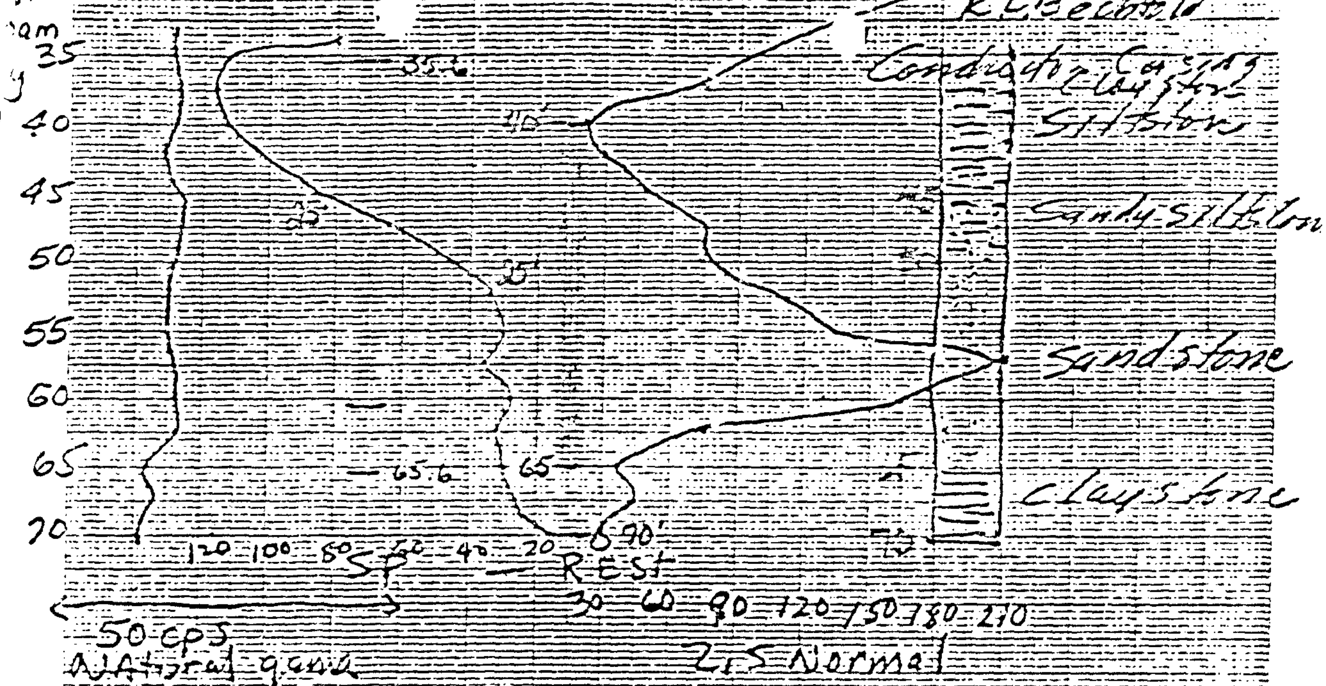


Set screens according to contract drawings
7/6/81 2:00pm Cindy

Reck.
7/ 81
10: am
C...y

PW-49

Logged July 1981
K L Bechtold

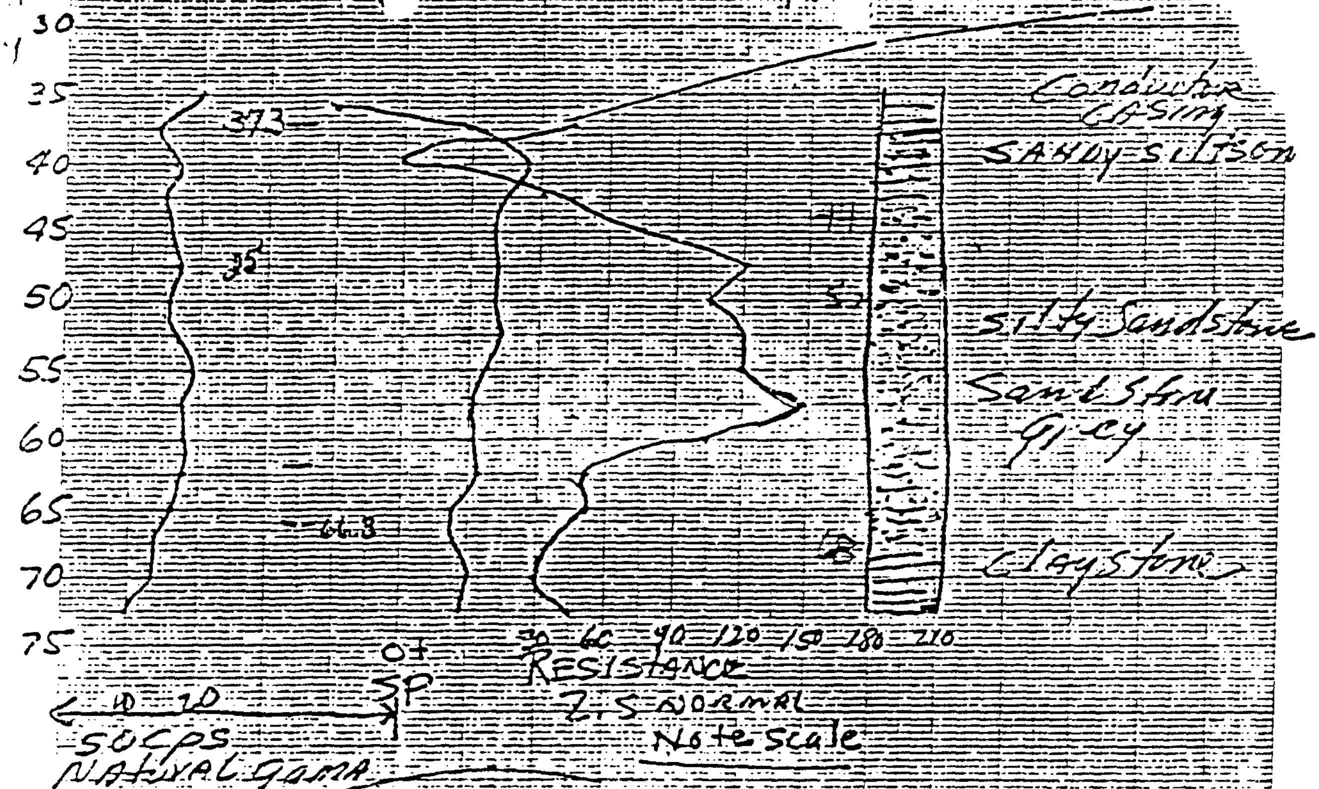


Set screen 40'-65'
Total depth of well 70'
7/6/81
2:00pm
Cindy

Rec'd
10:[illegible] am

DW-50

Logged July [illegible]
By K. Bechtold

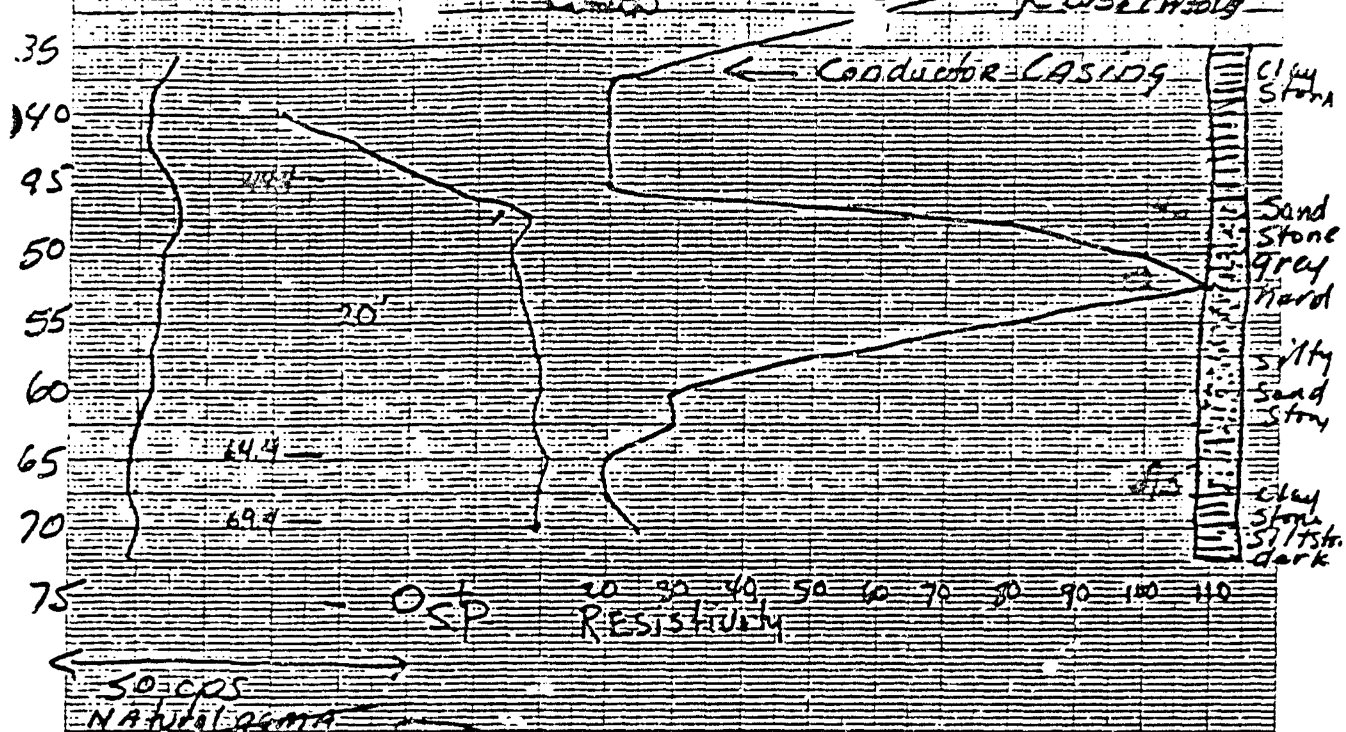


Set according to contract drawings

Cindy
2:00 pm
7/6/81

DW-51' Rec'd 10:30am 7/3/81 Logged July 1, 1981

K.W. Bechtold



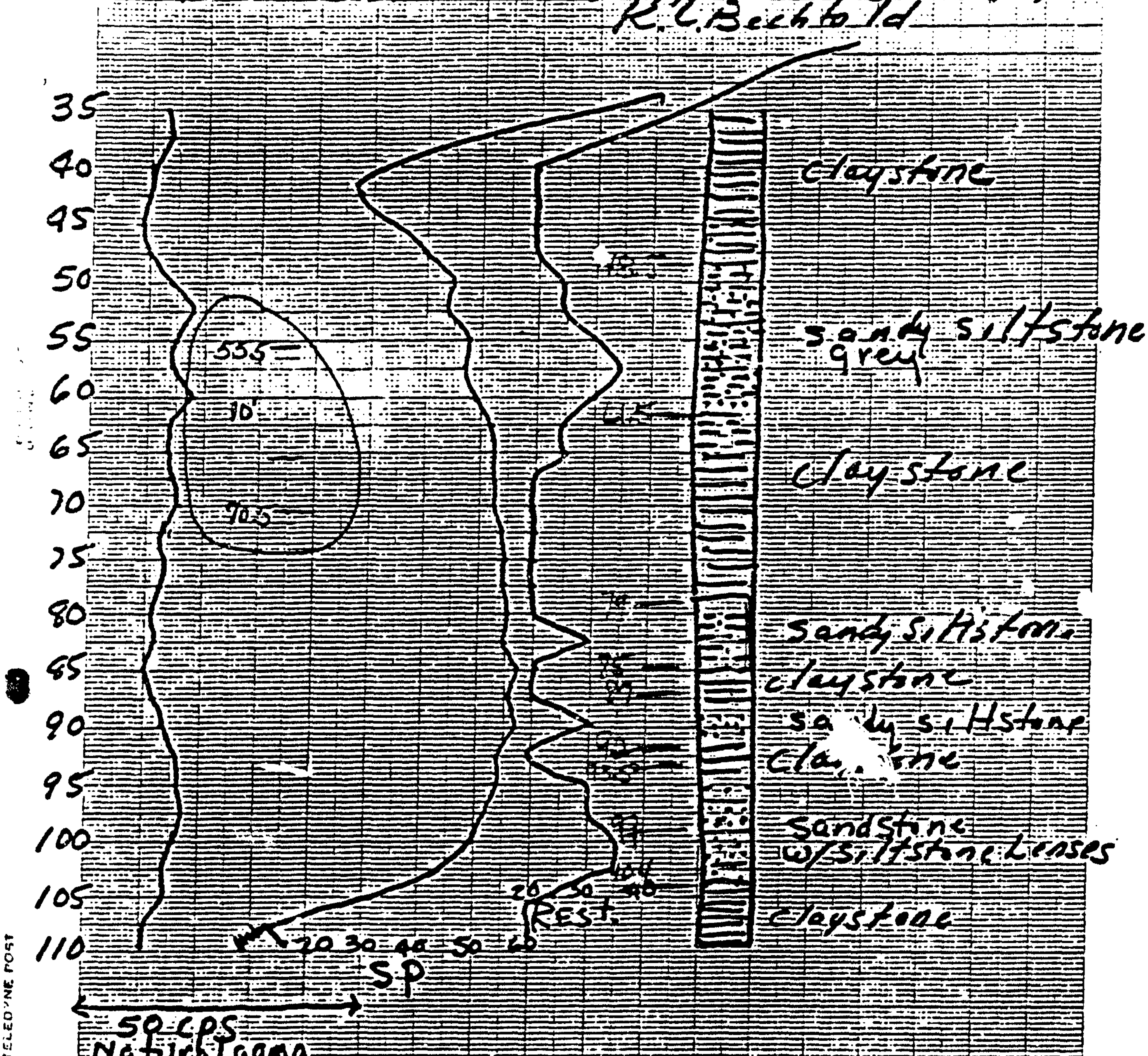
Set screens according to contract drawings

7/3/81 11:00am

Rec'd 12:30pm 7/1/81
C.H. Smith

DW-52

Logged June 30, 1981
K.L. Bechtold

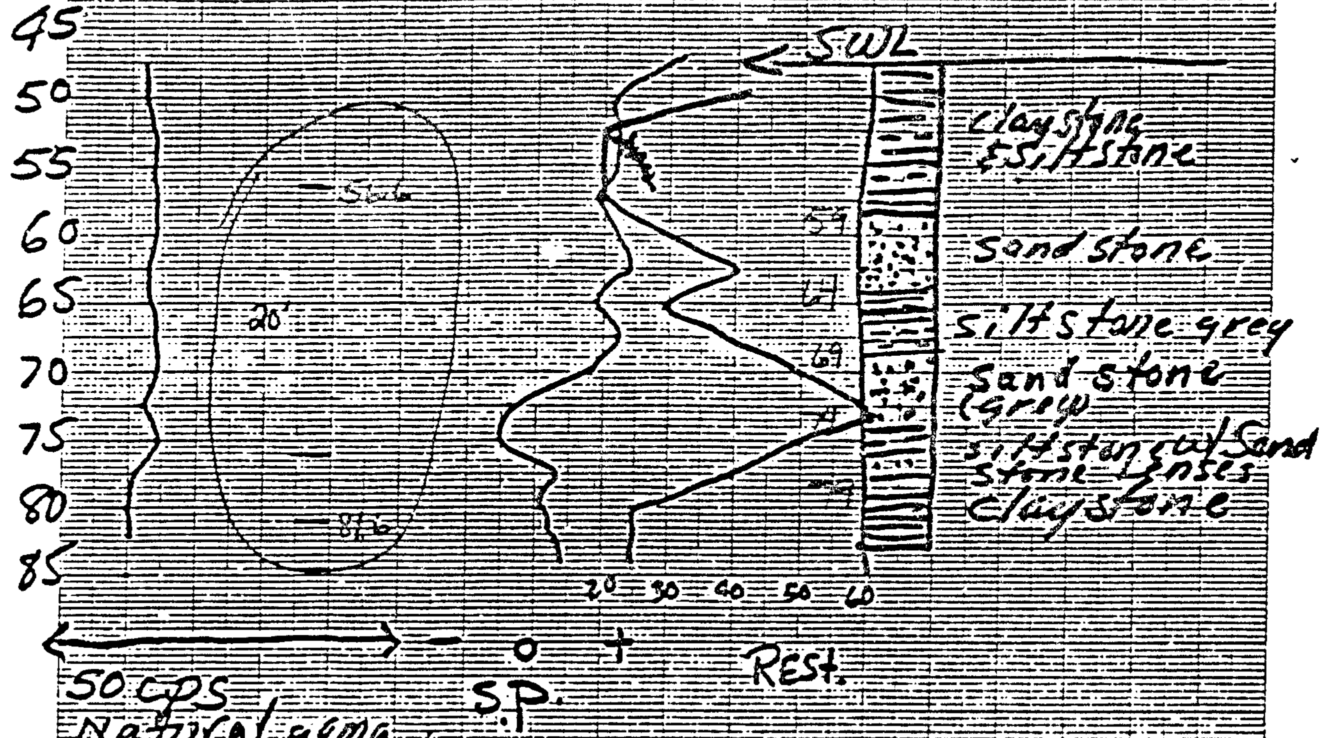


Set screen
per contract drawings
2:00
7/1/81

Rec'd 12:30 pm 7/1/81
Smith

DW-53

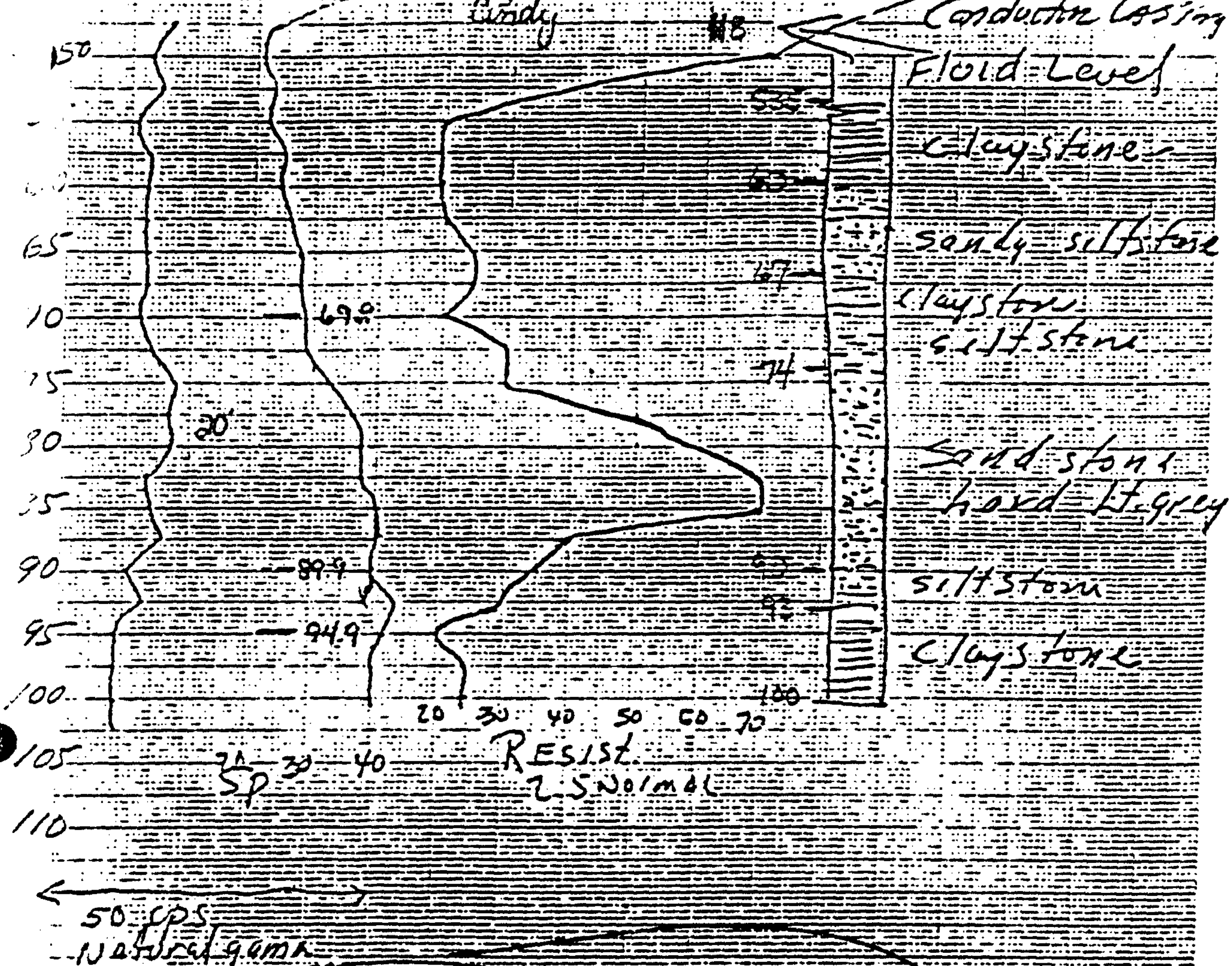
Logged June 30 1981
By K.L. Bechtold



Set Screen
per contract dwgs.
Cin
2:00
7/1/81

DW-54

Rec'd 10:00am Logged July 7, 1988.
7/6/81
Cindy



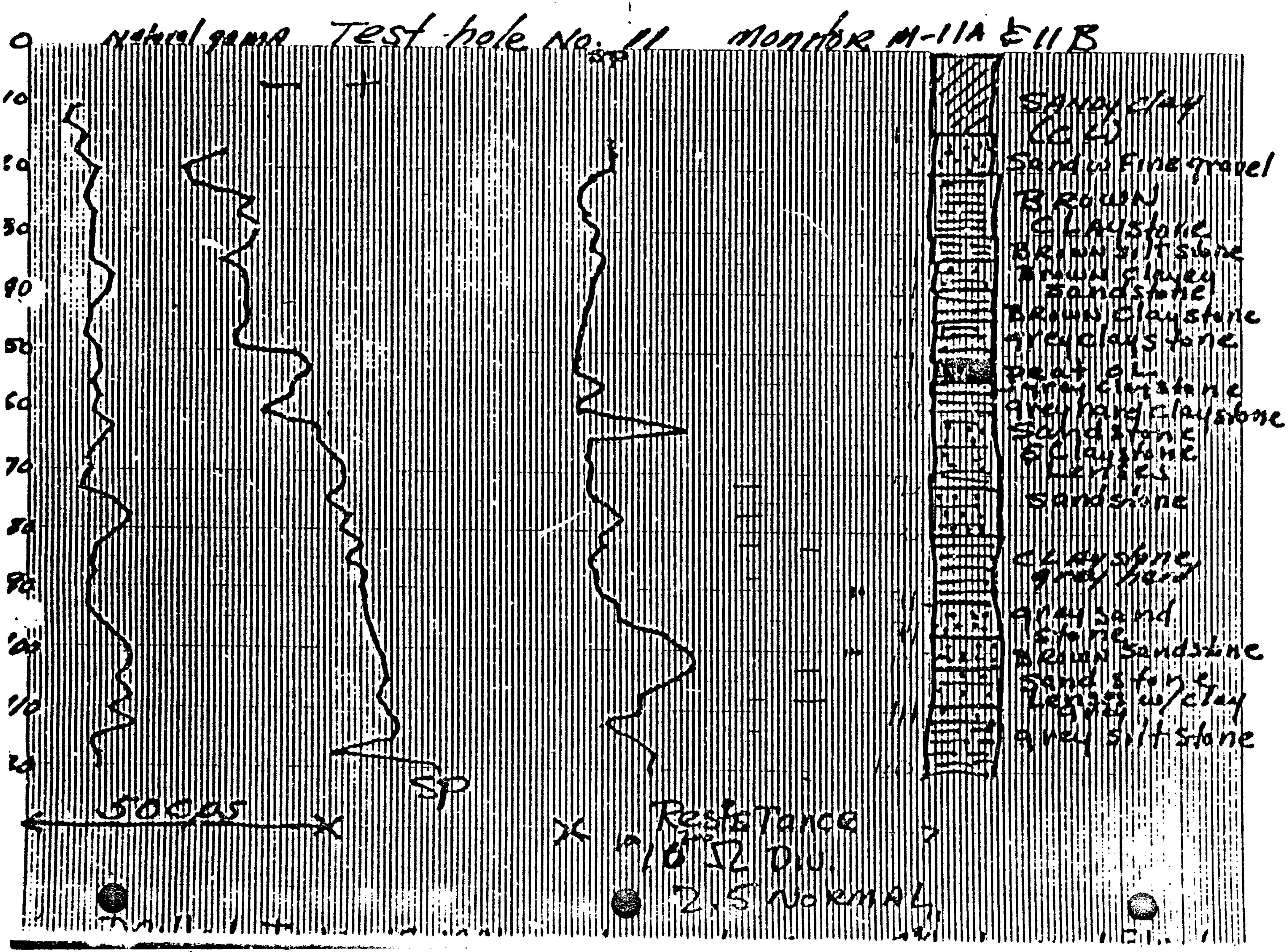
Set screen according to contract drawing
7/6/81 2:00pm Cindy

APPENDIX B

Electric Logs for
Monitoring Wells
M-11, M-15, M-18, M-20, and M-38

K·E

47 1322



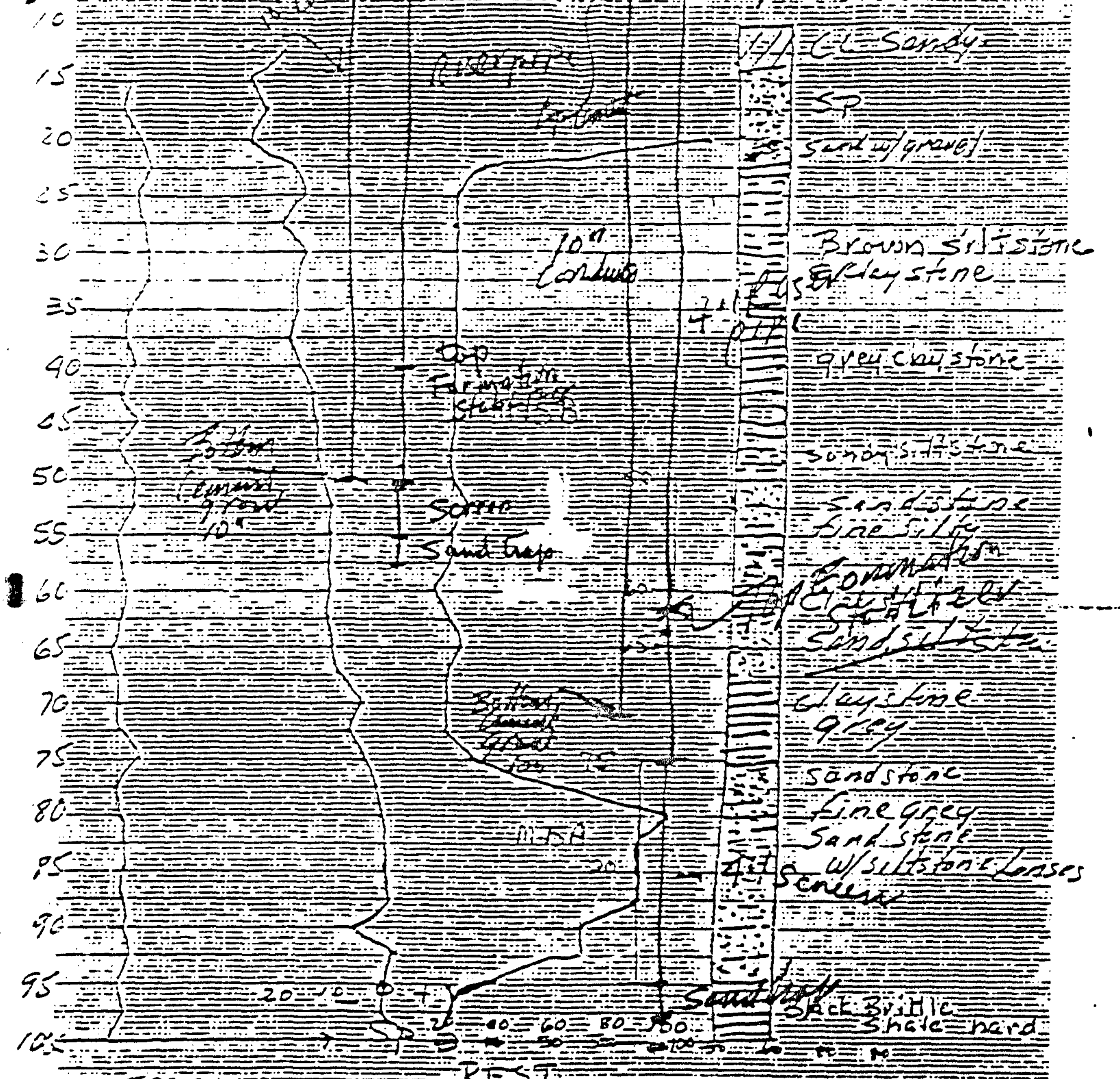
Natural gamma Test hole No. 11 Monitor M-11A & 11B
0
10
20
30
40
50
60
70
80
90
100
110
120
SP
500 cps
Resistance 16 32 D.U. 2.5 Normal
Sandy clay (CL)
Sand w fine gravel
Brown claystone
Brown siltstone
Brown clayey sandstone
Brown claystone
Grey claystone
Peat
Grey claystone
Grey hard claystone
Sandstone & claystone lenses
Sandstone
Claystone grey hard
Grey sandstone
Brown sandstone
Sandstone lenses w/clay
Grey siltstone

3:36 pm 7/28 Cindy

Test hole 15

Sands Monitoring Well

Logged July 20, 1981



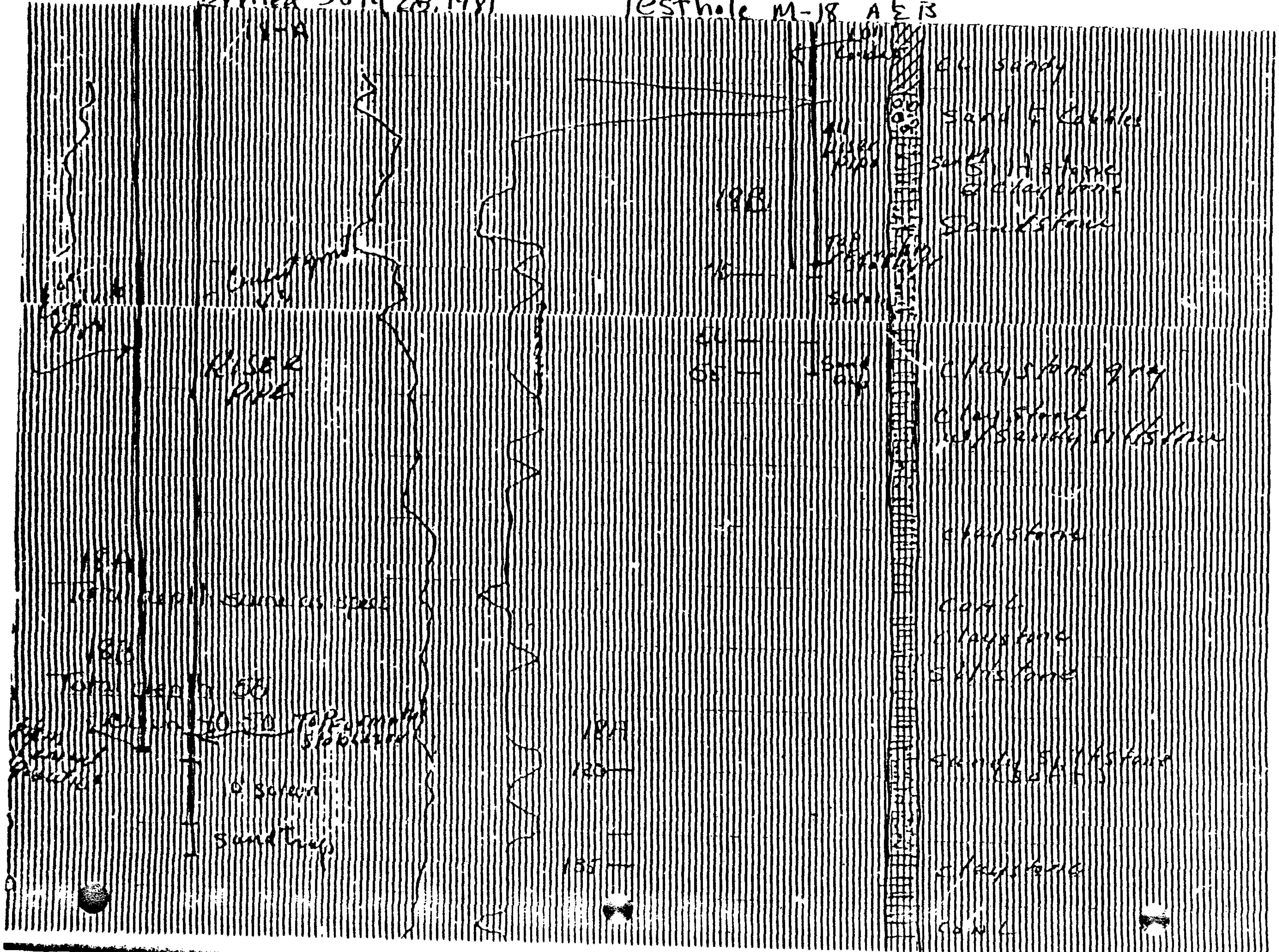
M-15A Total depth 100'
Screen set 75-95

M-15B Total depth 65
Screen set 50-60

K-E

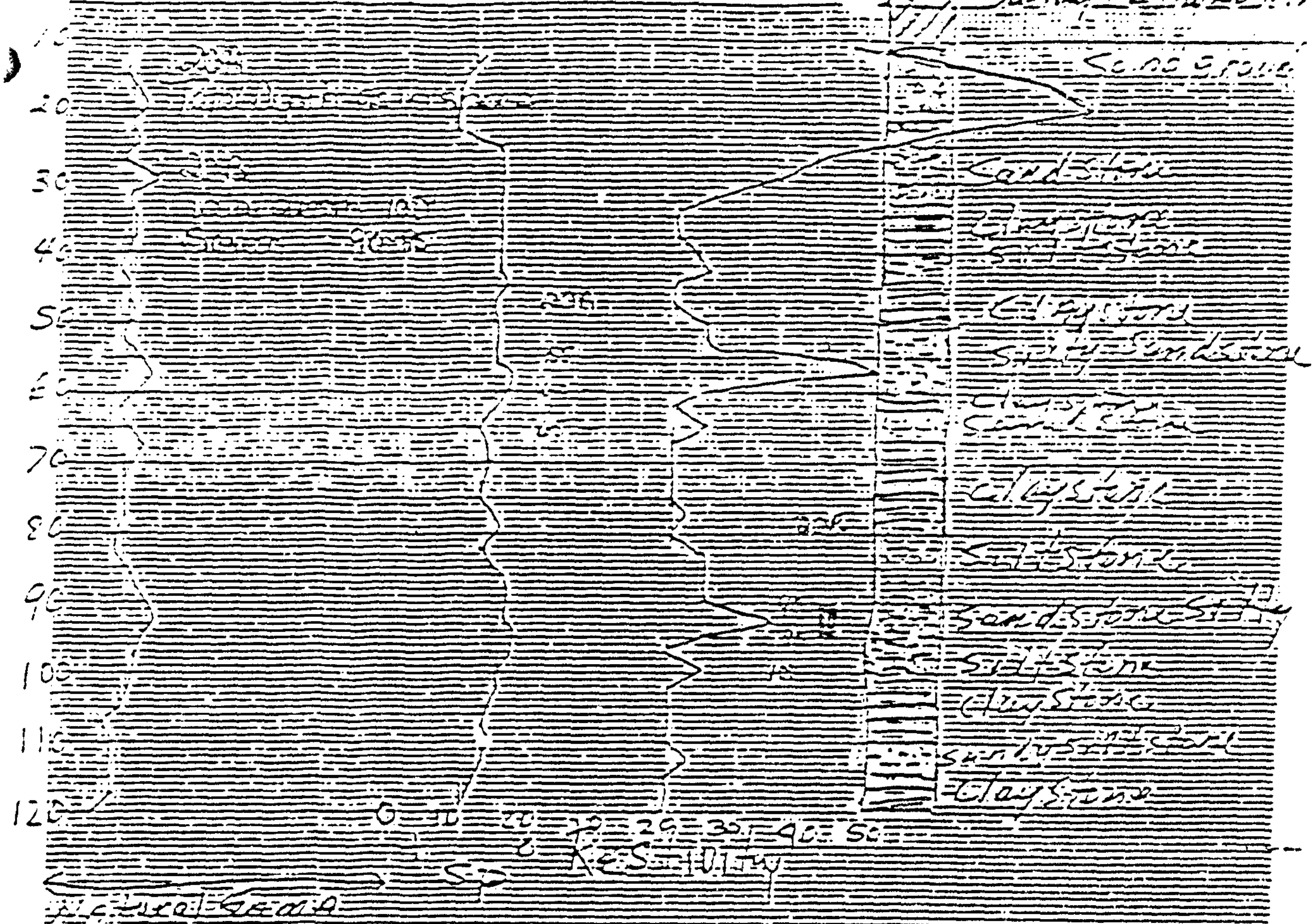
47 1322

Drilled July 28, 1981   Testhole M-18 A & B

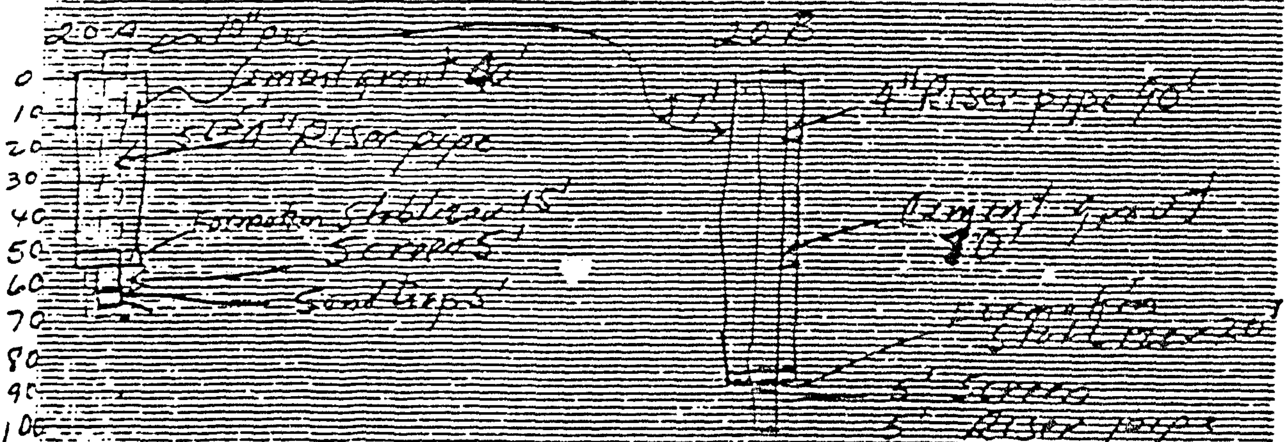


7/23/81 Cindy

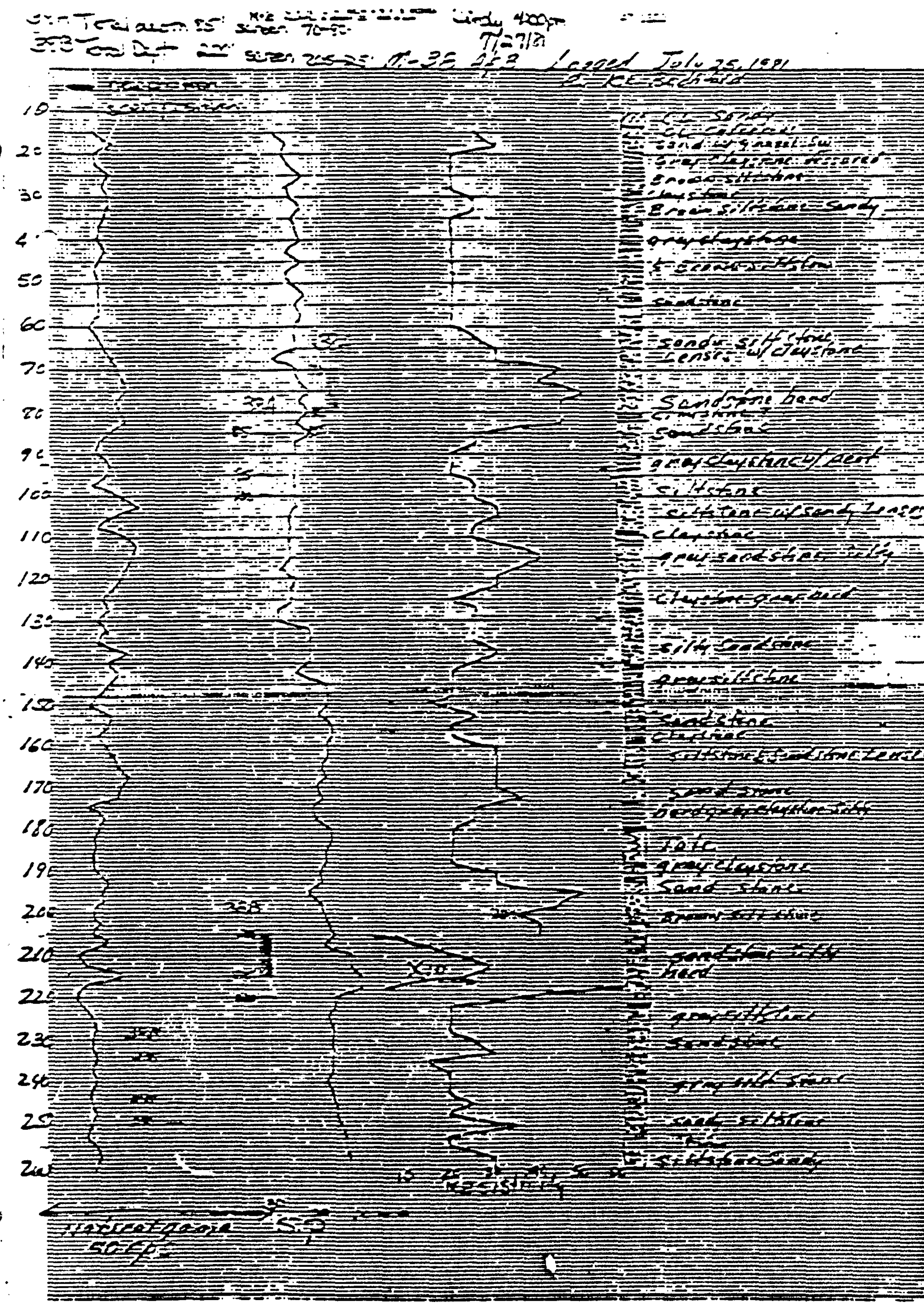
Log Testhole M-20



Casing Schedule



Drillers Log Same as Test hole Log
Test hole Used as pilot hole for M-20B


Logged July 25, 1981
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
Brown siltstone
claystone
sandstone
Sandstone band
sandstone
siltstone
claystone
silty sandstone
Sandstone
Claystone
gray claystone
Sand stone
gray siltstone
Sandstone
sandy siltstone
Resistivity
S.P.
50 cps

APPENDIX C

As-Built Well Data

ALLUVIAL DEWATER WELLS

4 HOUR PUMP TEST

Well #	Method Drilled	Depth	Screen Depth	Material Screen Set	Date	Before/During/After Drawdown	Flow
DW 1R	Reverse Rotary	21'	14'-17'	SP, clayey	9-10-81	18'/18'/18'	6gpm
DW 2R	Reverse Rotary	19.5'	12.5'-15.5'	SP	9-10-81	17.2'/17.2'/17.2'	5gpm
DW 3R	Reverse Rotary	22'	15'-18'	SP-GP	9-9-81	15'/15.1'/15.1'	40gpm
DW 4R	Reverse Rotary	30'	22'-26'	Cemented Sand and SP	9-9-81	22.3'/22.3'/22.3'	40gpm
DW 5R	Reverse Rotary	34.5'	22.5'-30.5'	Cemented SP-GP and GP w/ Cobbles	9-9-81	28'/28'/28'	40gpm
DW 6R	Reverse Rotary	32'	23'-28'	SP-GP	9-7-81	27.8'/27.9'/27.9'	40gpm
DW 7	Reverse Rotary	30'	23'-26'	Cemented Sand + gravel w/ Cobbles	4-22-81	23.5'/23.5'/23.5'	9gpm
DW 8	Reverse Rotary	29'	22'-25'	Cemented SP-GP w/ Cobbles	4-22-81	24.3'/24.3'/24.4'	17gpm
DW 9	Reverse Rotary	30'	20'-26'	Cemented SP-GP w/ Cobbles	4-21-81	15.4'/15.4'/15.4'	16gpm
DW 10	Reverse Rotary	32'	18'-28'	Cemented SP-GP and SP-GP	4-20-81	26.1'/26.1'/26.1'	24gpm
DW 11	Reverse Rotary	27.5'	16.5'-23.5'	Cemented SP-GP w/ Cobbles	4-20-81	19.4'/19.4'/19.4'	30gpm
DW 12	Reverse Rotary	28.7'	17.7'-24.7'	Cemented SP-GP w/ Cobbles	4-20-81	25.3'/25.25'/25.3'	26gpm
DW 13	Reverse Rotary	29.9'	16.9'-25.9'	Cemented SP-GP w/ Cobbles	4-18-81	18.5'/18.5'/18.5'	34gpm
DW 14	Reverse Rotary	30.[illegible]'	15.1'-26.1'	Cemented SP-GP w/ Cobbles	4-17-81	16.85'/16.85'/16.85	34gpm
DW 15	Reverse Rotary	28.7'	14.7'-24.7'	Sandy Gravel Cemented SP-GP	4-16-81	12.7'/12.75'/12.75	34gpm
DW 16	Reverse Rotary	26'	12'-22'	Clayey Sand	4-27-81	12.2'/12.2'/12.25'	35gpm
DW 17	Reverse Rotary	24'	13'-20'	Clayey Sand	4-27-81	10.0'/10.0'/10.0'	42gpm
DW 18	Reverse Rotary	27'	15'-23'	Silty Sand	4-27-81	10.5'/10.5'/10.[illegible]'	51gpm
DW 19	Reverse Rotary	27'	13'-23'	Gravel w/ Cobbles	4-8-81	10.4'/10.4'/10.45'	60gpm

ALLUVIAL DEWATER WELLS

WELL #	METHOD DRILLED	DEPTH	SCREEN DEPTH	MATERIAL SCREEN SET	DATE	4 HOUR PUMP TEST BEFORE/DURING/AFTER DRAWDOWN	FLOW
DW 20	REVERSE ROTARY	28'	16' - 24'	SP-GP w/ Cobbles	4-9-81	10.0'/10.0'/10.0'	65gpm
DW 21	REVERSE ROTARY	31'	19'-27'	Sandy Gravel w/ Cobbles	4-10-81	11.7'/11.7'/11.7'	65gpm
DW 22	REVERSE ROTARY	25'	12' - 21'	Gravel w/ Cobbles and Boulders	5-11-81	14.5'/14.6'/14.6'	60gpm
DW 23	REVERSE ROTARY	30'	13' - 26'	Sandy Gravel, Gravel w/ Cobbles	5-12-81	25.1'/25.15'/25.15	35gpm
DW 24	REVERSE ROTARY	27'	14' - 23'	Sandy Gravel, Gravel w/ Cobbles	5-12-81	22.5'/22.5'/22.55	3.5gpm
DW 25	REVERSE ROTARY	26'	14' - 22'	Silty Gravel, SP-GP w/ Cobbles	5-14-81	22.2'/22.3'/22.3'	4.5gpm
DW 26	REVERSE ROTARY	28'	15' - 24'	Silty Sand, Sand	5-18-81	22.4'/22.4'/22.4'	35gpm
DW 27	REVERSE ROTARY	28'	15' - 24'	FINE SAND	5-18-81	22.1'/22.1'/22.2'	15gpm
DW 28	REVERSE ROTARY	26'	15' - 22'	Sandy Clay	5-19-81	9.7'/9.7'/9.7'	15gpm
DW 29	REVERSE ROTARY	32'	23' - 28'	SP-GP	5-20-81	26.3'/26.3'/26.35'	12gpm
DW 30	BUCKET AUGER	32.5'	25.5' - 28.5'	GW - to 3"	3-20-81	28.5'/29.6'/29.6'	1/2gpm
DW 31	BUCKET AUGER	25.8'	17.8' - 21.8'	SP-GP to 3"	3-17-81	21.6'/21.5'/21.5'	1gpm
DW 32	BUCKET AUGER	25.5'	16.5' - 21.5'	Clay w/ some Sand	3-17-81	19.9'/20.1'/20.5'	24gpm
DW 33	BUCKET AUGER	25'	216' - 21'	Sand w/ gravel	3-17-81	21.4'/21.5'/21.8'	30gpm
DW 34	BUCKET AUGER	26'	14' - 22'	V. Clayey Sand SW w/ small gravel	3-18-81	21.3'/22.7'/24.4'	40gpm
DW 35	BUCKET AUGER	22.8'	13.8' - 18.8'	Sandy Clay and Gravel	3-18-81	21.4'/21.5'/21.8'	10gpm

DENVER FORMATION SANDSTONE DEWATER WELLS

4 HOUR PUMP TEST

WELL #	METHOD DRILLED	DEPTH	SCREEN DEPTH	MATERIAL SCREEN SET	DATE	BEFORE/DURING/AFTER DRAWDOWN	FLOW
DW36	ROTARY, AIR ROTARY	119.5'	79.5'-89.5' 94.5'-114.5'	Clayey Sandstone, some sandstone	7-15-81	97.0'/97.0'/97.0'	1 gpm
DW37	ROTARY, AIR ROTARY	67.5'	33.5'-43.5' 57.5'-62.5'	fine Clayey Sandstone claystone	7-16-81	60.2'/60.2'/60.25'	1 gpm
DW38	Rotary, Air Rotary	60.9'	27.9'-42.9' 50.9'-55.9'	Claystone, Clayey Sandstone	7-16-81	48.8'/48.85'/48.85'	4 gpm
DW39	Rotary, Air Rotary	56.0'	31'-51'	Sandy Claystone, Claystone sandy lenses	7-16-81	41.0'/41.0'/41.0'	2 gpm
DW40	Rotary, Air Rotary	64.0'	39'-59'	Sandy Claystone, Clayey Sandstone	7-16-81	58.6'/58.6'/58.6'	2 gpm
DW41	Rotary Air Rotary	65.0'	40'-60'	Claystone w/ sandy lenses	7-17-81	60.1'/60.1'/60.15'	1 gpm
DW42	Rotary, Air Rotary	112.0'	87'-107'	Sandstone	7-25-81	98.5'/98.5'/98.5'	6 gpm
DW43	Rotary, Air Rotary	59.0'	39'-54'	Siltstone w/ sandstone lenses	7-25-81	56.1'/56.1'/56.1'	1/4 gpm
DW44	Rotary, Air Rotary	66.0'	51'-61'	Sandstone, Claystone	7-25-81	60.0'/60.0'/60.1'	1/8 gpm
DW45	Rotary, Air Rotary	65.0'	40'-60'	Silty Sandstone, Claystone	7-24-81	61.2'/61.2'/61.3'	1/8 gpm
DW46	Rotary Air Rotary	65.0'	50'-60'	Claystone, Sandstone	7-24-81	61.3'/61.3'/61.3'	1/4 gpm
DW47	Rotary Air Rotary	90.9'	50.9'-60.9' 75.9'-85.9'	Sandy Siltstone, Siltstone, Claystone	7-23-81	85.3'/85.3'/85.3'	1/8 gpm
DW48	Rotary Air Rotary	91.5'	51.5'-56.5' 76.5'-86.5'	Siltstone Sandy Siltstone	7-24-81	85.3'/85.3'/85.3	1/8 gpm
DW49	Rotary, Air Rotary	70.0'	40'-65'	Siltstone, sandy, sandstone	7-18-81	65.2'/65.2'/65.3'	5 gpm
DW50	Rotary, Air Rotary	67.3'	37.3'-62.3'	Sandy Siltstone, Silty Sandstone, Sandstone	7-18-81	59.7'/59.7'/59.7'	5 gpm
DW51	Rotary, Air Rotary	69.4'	44.4'-64.4'	Sandstone, Silty Sandstone	7-21-81	62.7'/62.7'/62.7'	1/4 gpm
DW52	Rotary, Air Rotary	70.5'	55.5'-65.5'	Sandy Siltstone Claystone	7-22-81	64.0'/64.0'/64.0'	1/8 gpm
DW53	Rotary, Air Rotary	81.6'	56.6'-76.6'	Sandstone, Siltstone	7-22-81	75.1'/75.2'/75.2'	1/8 gpm
DW54	ROTARY, Air Rotary	91.9'	69.9'-89.9'	Sandstone	7-23-81	89.4'/89.4'/89.4'	1/8 gpm

RECHARGF WELLS

					4 HOUR PUMP TEST			INFILTRATION TEST		
WELL #	METHOD DRILLED	DEPTH	SCREEN DEPTH	MATERIAL SCREEN SET	DATE	BEFORE/DURING/AFTER DRAWDOWN	FLOW	AMOUNT ADDED	STATIC LEVEL	TIME TO REACH STATIC
RW13	BUCKET AUGER	23.7'	12.7'–19.7'	SAND	4-2-81	20.3'/20.3'/20.4'	23 gpm	138 gal.	16.2'	40 min.
RW14	BUCKET AUGER	18.0'	7'–14.0'	Sandy Clay, SP-GP	3-31-81	13.7'/14.0'/14.3'	5 gpm	139 gal.	10.60'	45 min.
RW15	REVERSE ROTARY	19.5'	8.5'–15.5'	Sandy Clay, cemented SP-GP	4-6-81	17.8'/17.8'/17.8'	17 gpm	258 gal	10.10'.	23 min.
RW16	REVERSE ROTARY	21.2'	6.2'–17.2'	Clayey Sand, Sandy Clay, cemented SP-GP	4-6-81	14.8'/14.8'/14.85'	30 gpm	293 gal.	9.9'	25 min.
RW17	REVERSE ROTARY	24.0'	8'–20'	Sandy Clay, Cemented SP-GP, Sand w/Cobbles	4-7-81	12.2'/12.3'/12.3'	36 gpm	285 gal	9.7'	30 min.
RW18	REVERSE ROTARY	22.0'	6'–18'	Sandy Clay, Fine Sand	4-7-81	7.6'/7.65'/7.65'	34 gpm	124 gal	6.1'	11 min.
RW19	REVERSE ROTARY	23.5'	9.5'–19.5'	Sandy Clay, Sandy Gravel	4-8-81	18.6'/18.65'/18.7'	7 gpm	63 gal	6.7'	35 min.
RW20	REVERSE ROTARY	22.5'	8.5'–19.5'	Sandy Clay, Sandy Gravel	4-14-81	18.3'/18.3'/18.35'	19 gpm	146 gal	7.1'	30 min.
RW21	REVERSE ROTARY	22.9'	8.9'–18.9'	Sandy Clay, Silty Sand	4-15-81	19.3'/19.3'/19.3'	34 gpm	166 gal.	6.7'	25 min.
RW22	REVERSE ROTARY	25'	9'–21'	Sandy Clay, SP-GP	4-15-81	12.0'/12.0'/12.0'	34 gpm	172 gal	6.1'	30 min.
RW23	REVERSE ROTARY	24'	9'–20'	Clayey Sand, SP-GP w/Cobbles	5-22-81	13.3'/13.3'/13.3'	65 gpm	300 gal	6.2'	5 min.
RW24	REVERSE ROTARY	28'	13'–24'	Clayey Sand, SP-GP w/Cobbles	5-26-81	15.4'/15.4'/15.45'	65 gpm	300 gal	8.25'	5 min.
RW25	REVERSE ROTARY	34'	15'–30'	Clayey Sand, Sand and Clay w/Cobbles	5-29-81	16.6'/16.65'/16.65'	65 gpm	400 gal	9.5'	5 min.
RW26	REVERSE ROTARY	33'	14'–29'	Silty Sand, SP-GP w/Cobbles	6-1-81	21.5'/21.5'/21.6'	65 gpm	500 gal	11.1'	5 min.
RW27	REVERSE ROTARY	33'	14'–29'	SP-GP w/Cobbles	5-26-81	28.0'/28.0'/28.0'	20 gpm	400 gal	12.4'	15 min.

RECHARGE WELLS

					4 HOUR PUMP TEST			INFILTRATION TEST		
WELL #	METHOD DRILLED	DEPTH	SCREEN DEPTH	MATERIAL SCREEN SET	DATE	BEFORE/DURING/AFT DRAWDOWN	FLOW	AMOUNT ADDED	STATIC LEVEL	TIME TO REACH STATIC
RW28	Reverse Rotary	32'	12'-28'	Clayey Sand, Sand	5-26-81	26.4'/26.4'/26.4'	25 gpm	350gal	13.2'	45 min.
RW29	Reverse Rotary	32'	13'-28'	Silty Sand, SP-GP	5-27-81	26.7'/26.7'/26.8'	1/2 gpm	400gal	18.5'	60 min.
RW30	Reverse Rotary	34'	19'-30'	Silt w/Clay layers SP-GP w/clay	5-28-81	30.1'/30.15'/30.2'	3gpm	425gal	26.2'	35 min.
RW31	Reverse Rotary	37'	23'-33'	Silt w/Clay layers SP-GP w/Clay	5-29-81	33.2'/33.2'/33.3'	1/4 gpm	450gal	31.1'	50 min.
RW32	Bucket Auger	25'	16'-21'	Silt	3-24-81	20.10'/20.55'/20.80'	1 gpm	134gal	11.25'	1470min.
RW33	Bucket Auger	18'	8'-14'	Clay w/Sand lenses Clay	3-24-81	15'/15'/15'	1/8 gpm	149gal	9.0'	1465 min.
RW34	Bucket Auger	25'	11'-21'	Weathered claystone w/sand lenses	3-25-81	21.8'/21.9'/22.8'	1/8 gpm	167gal	9.0'	1460 min.
RW35	Bucket Auger	17'	7'-13'	Sp w/ gravel, Clay w/ gravel	3-25-81	15.5'/15.5'/15.5'	1/8 gpm	131gal	8.0'	1455 min.
RW36	Reverse Rotary	19.6'	7.6'-15.6'	Sandy Clay	3-25-81	16.3'/17.0'/17.9'	3/4 gpm	124gal	9.65'	1440min.
RW37	Bucket Auger	22'	8'-18'	Clay w/Sand, Sand	3-26-81	18.0'/18.0'/18.2'	15gpm	116gal	10.0'	95 min.
RW38	Reverse Rotary	24.6'	9.6'-20.6'	Sandy Clay, Fine Sand	3-26-81	22.6'/22.8'/21.70'	4gpm	176gal	11.0'	90min.

MONITORING WELLS

2 HOUR PUMP TEST

Well #	Method Drilled	Depth	Screen Depth	Material Screen Set	Date	Before/During/After Drawdown		Flow
M-19	Rotary, Air Rotary	31'	16'-26'	SP-GP	8-14-81	12.1'	20.0'	10gpm
M-20A	Rotary, Air Rotary	65'	55'-60'	Silty Sandstone	8-10-81	14.5'	56.3'	2gpm
M-20B	Rotary, Air Rotary	100'	90'-95'	Silty Sandstone	8-10-81	12.1'	91.3'	2gpm
M-21	Rotary, Air Rotary	28'	13'-23'	Sand	8-7-81	6.5'	12.0'	10gpm
M-22	Rotary Air Rotary	20'	10'-15'	Silty, Clayey Sand	7-28-81	11.1'	19.0'	2gpm
M-23	Rotary, Air Rotary	28'	18'-23'	Sand, Claystone	7-29-81	8.4'	10.1'	5gpm
M-24	Rotary, Air Rotary	27'	12'-22'	Sand	7-30-81	11.3'	13.2'	10gpm
M-25	Rotary, Air Rotary	24'	14'-19'	SP-GP	7-31-81	8.5'	8.4'	10gpm
M-26	Rotary, Air Rotary	29'	14'-24'	SP-GP	7-31-81	7.0'	8.7'	10gpm
M-27	Rotary, Air Rotary	21'	11'-16'	SP-GP	7-31-81	3.4'	4.0'	10gpm
M-28	Rotary, Air Rotary	32'	17'-27'	SP-GP, Sandy Siltstone	8-13-81	16.5'	27.4'	.5gpm
M-29	Rotary, Air Rotary	31'	16'-26'	Sand w/ cobbles, Siltstone	8-11-81	5.0'	11.8'	10gpm
M-30	Rotary, Air Rotary	26'	11'-21'	Sand	8-7-81	7.5'	16.7'	10gpm
M-31	Rotary, Air Rotary	21'	11'-16'	Clayey Sand Sand	7-28-81	11.0'	15.0'	10gpm
M-32	Rotary, Air Rotary	28'	18'-23'	Sand	8-7-81	7.3'	8.4'	10gpm
M-33	Rotary, Air Rotary	30'	15'-25'	Clayey Sand	8-7-81	5.2'	9.1'	10gpm
M-34	Rotary, Air Rotary	20'	5'-15'	Clayey Sand, Sand	8-7-81	4.0'	6.2'	10gpm
M-35	Rotary, Air Rotary	23'	8'-18'	Sand	8-8-81	7.1'	7.9'	10gpm
M-36	Rotary, Air Rotary	22'	7'-17'	SP-GP	8-8-81	8.4'	9.7'	10gpm
M-37	Rotary, Air Rotary	24'	14'-19'	Clayey Sand	7-29-81	20.8'	21.0'	.5gpm

MONITORING WELLS

2 HOUR PUMP TEST

WELL #	METHOD DRILLED	DEPTH	SCREEN DEPTH	MATERIAL SCREEN SET	DATE	BEFORE/DURING/AFTER DRAWDOWN		FLOW
M-1	Reverse Rotary	24'	9'-19'	Saturated Clay	7-29-81	11.9'	23.6'	.5 gpm
M-2	Reverse Rotary	28'	13'-23'	Saturated Clay, Sand	7-29-81	12.8'	18.3'	4 gpm
M-3	Reverse Rotary	25'	15'-20'	SP-GP	7-30-81	13.7'	13.7'	4 gpm
M-4	Reverse Rotary	23'	13'-18'	SP-GP	7-31-81	11.4'	13.5'	10 gpm
M-5	Reverse Rotary	21'	11'-16'	SP-GP	8-1-81	10.3'	17.5'	8 gpm
M-6	Reverse Rotary	26'	11'-21'	SP-GP	7-31-81	12.0'	22.0'	10 gpm
M-7	Reverse Rotary	24' -	9'-19'	Sand	8-1-81	8.7'	11.3'	10 gpm
M-8	Reverse Rotary	30'	10'-25'	Sand w/ gravel Clay w/ Sand lenses	8-1-81	10.0'	11.6'	10 gpm
M-9	Reverse Rotary	31'	16'-26'	SP-GP	8-1-81	12.7'	17.2'	10 gpm
M-10	Reverse Rotary	29'	19'-24'	Claystone	7-29-81	14.6'	24.9'	1/8 gpm
M-11A	Rotary, Air Rotary	108'	83'-103'	Sandstone, Claystone	8-7-81	5.5'	81.3'	2 gpm
M-11B	Rotary, Air Rotary	82'	72'- 77'	Sandstone	8-7-81	7.3'	94.7'	6 gpm
M-12	Rotary, Air Rotary	30'	20'-25'	Silty Sandstone, Claystone	7-29-81	12.5'	30.0'	5 gpm
M-13	Rotary, Air Rotary	37'	27'-32'	Silty Sandstone	8-20-81	18.1'	28.3'	4 gpm
M-14	Rotary, Air Rotary	39'	28'-34'	Claystone w/ Sand lenses	8-20-81	18.7'	34.2'	1 gpm
M-15A	Rotary, Air Rotary	100'	75'-95'	Sandstone w/ Siltstone lenses	8-10-81	13.2'	93.4'	.5 gpm
M-15B	Rotary, Air Rotary	65'	50'-60'	Silty Sandstone	8-10-81	17.3'	61.2'	.5 gpm
M-16	Rotary, Air Rotary	23'	14'-19'	Clayey Sand	8-1-81	18.1'	19.0'	.5 gpm
M-17	Rotary, Air Rotary	17'	8'-13'	Sand	8-1-81	10.0'	17.2'	10 gpm
M-18A	Rotary, Air Rotary	135'	120'-130'	Sandy Siltstone	8-21-81	98.4'	129.4'	1.5 gpm
M-18B	Rotary, Air Rotary	55'	40'-50'	Sandstone	8-20-81	9.3'	47.4'	2 gpm
M 38A	Rotary, Air Rotary	85'	70'-80'	Sandy Siltstone	8-14-81	13.4	83.0	1 gpm
M 38B	Rotary, Air Rotary	220'	205'-215'	Silty Sandstone	8-15-81	90.0'	208.4'	2 gpm
M 39	Reverse Rotary	35.5'	20.5'-30.5'	Sand, Clay	7-29-81	23.4'	23.5'	.5 gpm

PHOTOGRAPHS

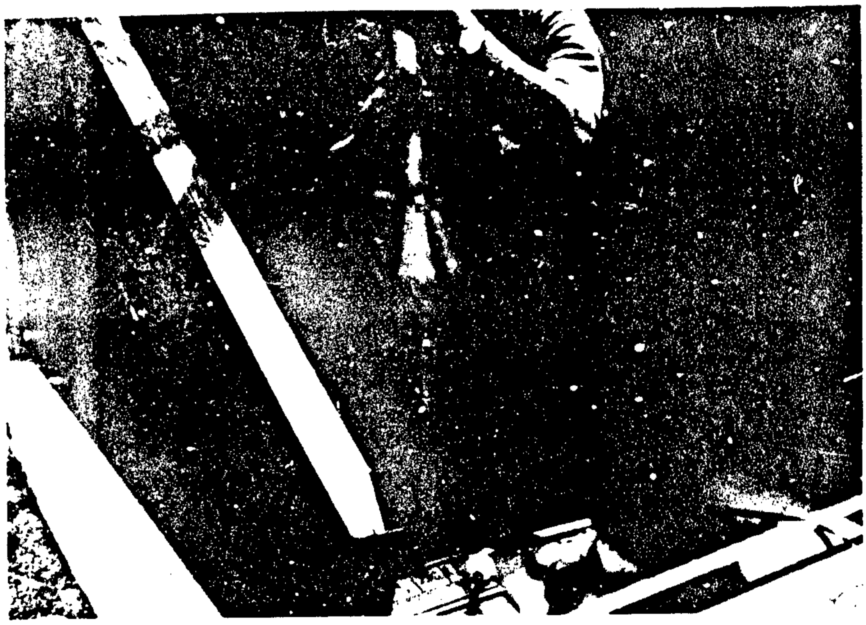


PHOTO 1 - CENTRALIZER DW 9
APRIL 29, 1981

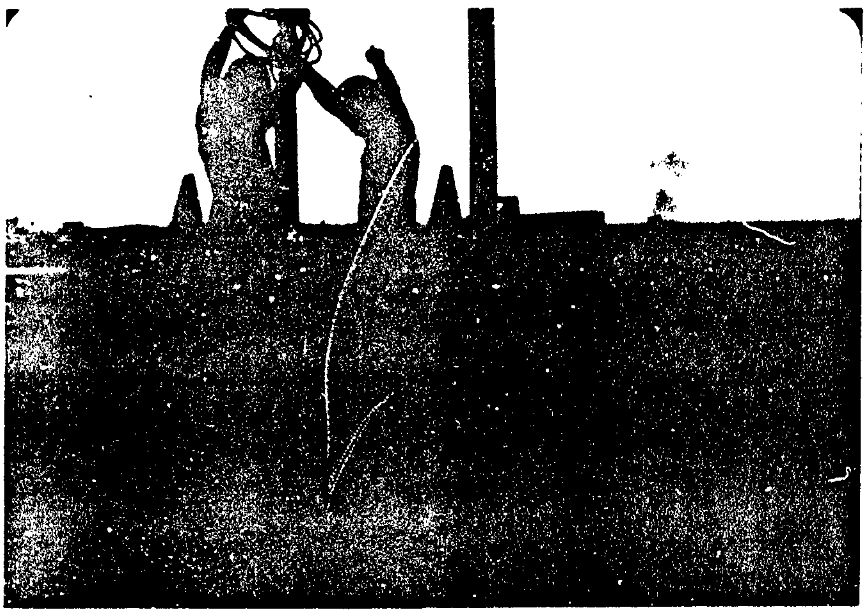


PHOTO 2 - PUMP BEING PLACED INTO WELL DW 9

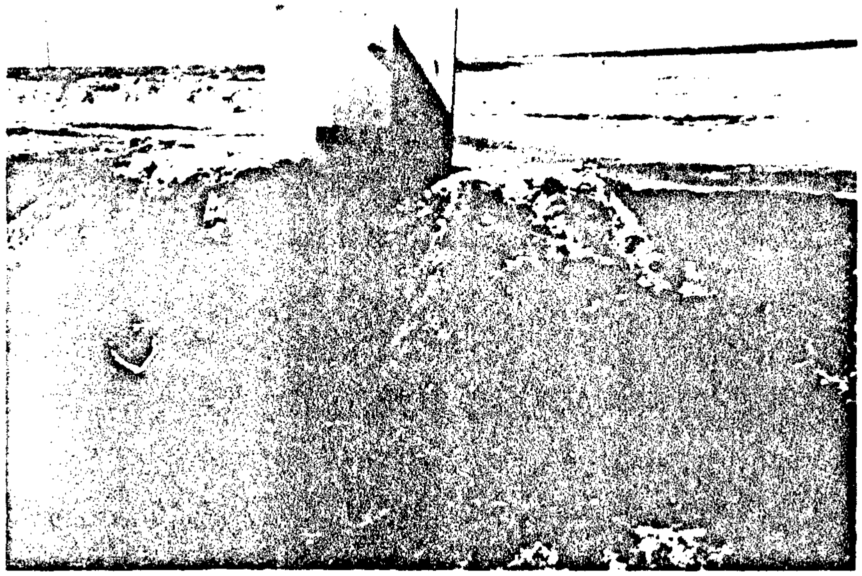


PHOTO 3 - SOUTH SIDE OF DW 26
JUNE 1981

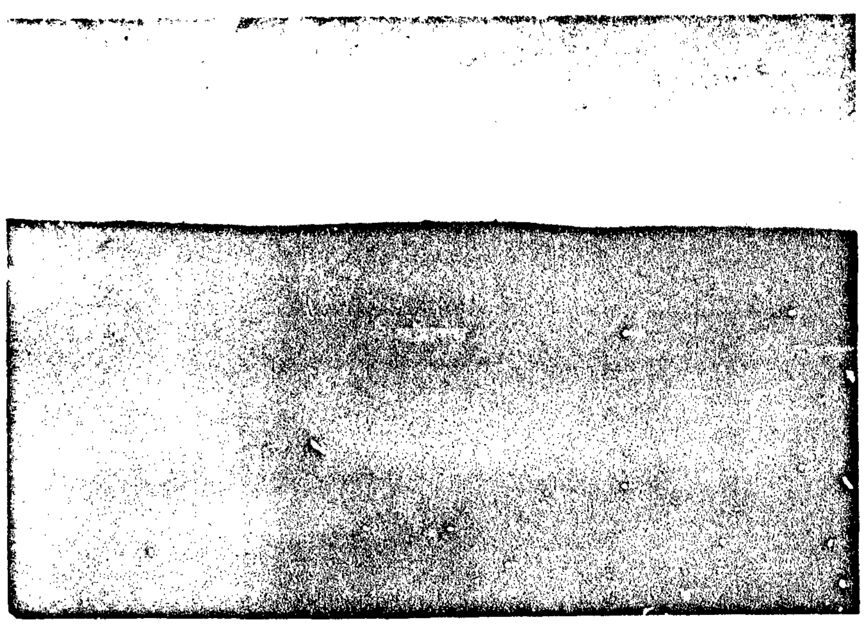


PHOTO 4 - MOUNDS FOR DEWATER WELLS 25-27
MAY 25, 1981

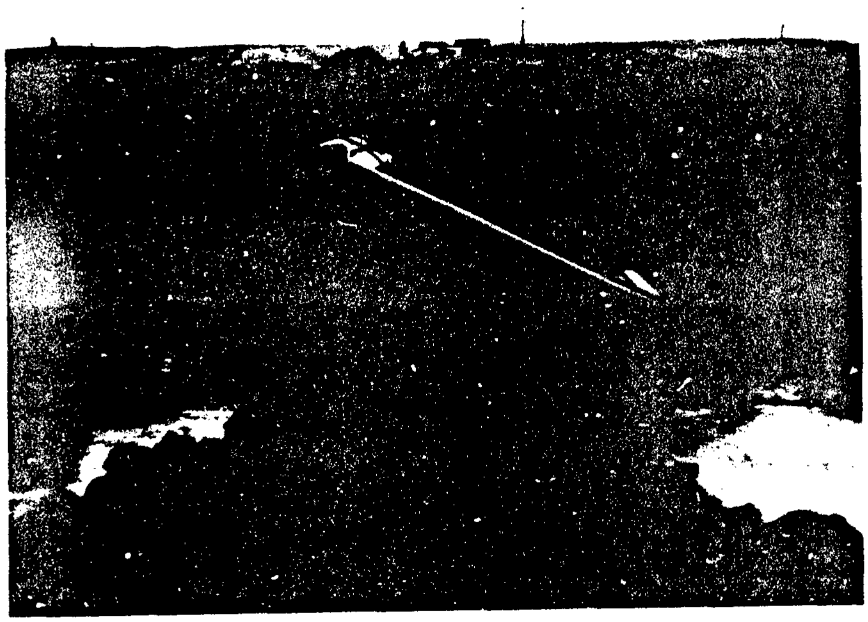


PHOTO 5 - GROUND WATER LOOKING EAST DW 47
JULY 23, 1981

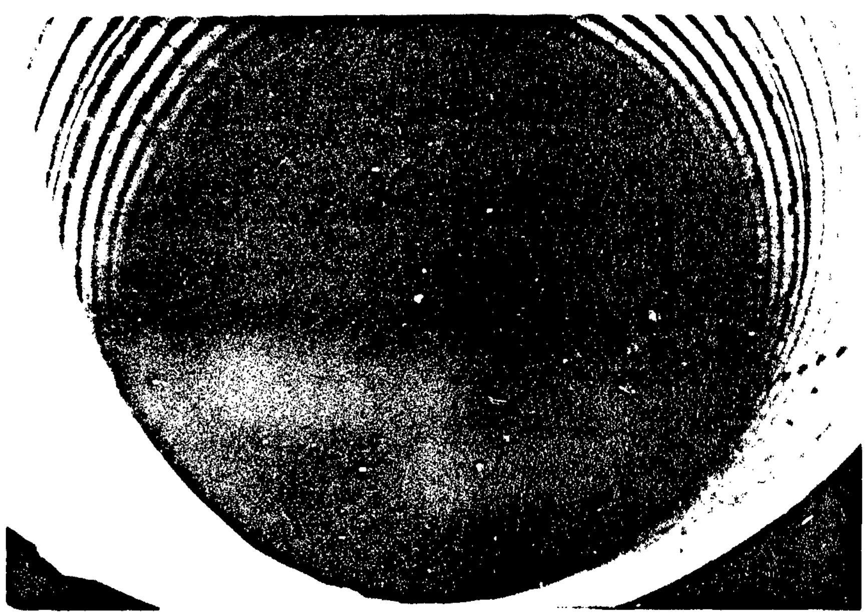


PHOTO 6 - RECHARGE WELL #1
MARCH 1981

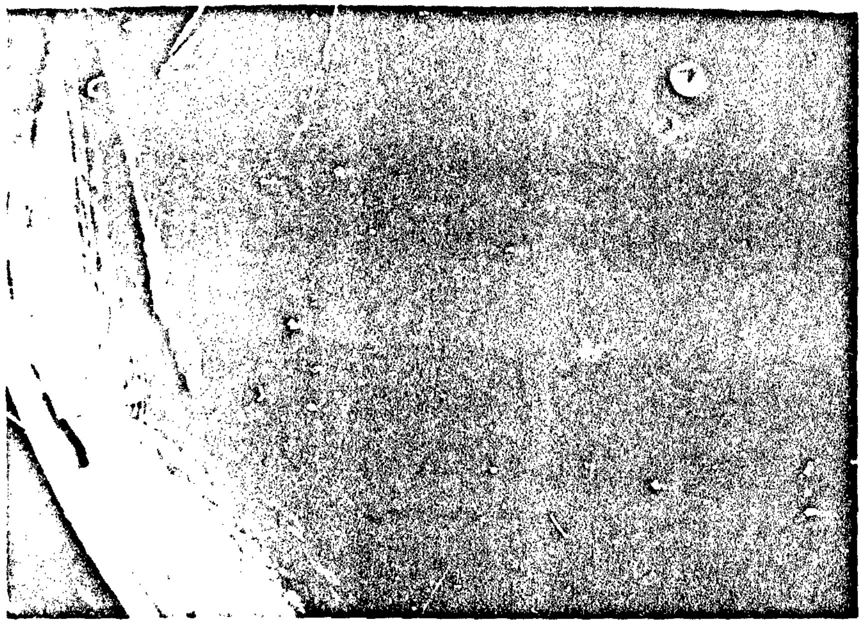


PHOTO 7 - RECHARGE WELL #1 CONTROLS
MARCH 1981

PHOTO 8 - EXISTING RECHARGE WELL CONDITIONS
MARCH 1981

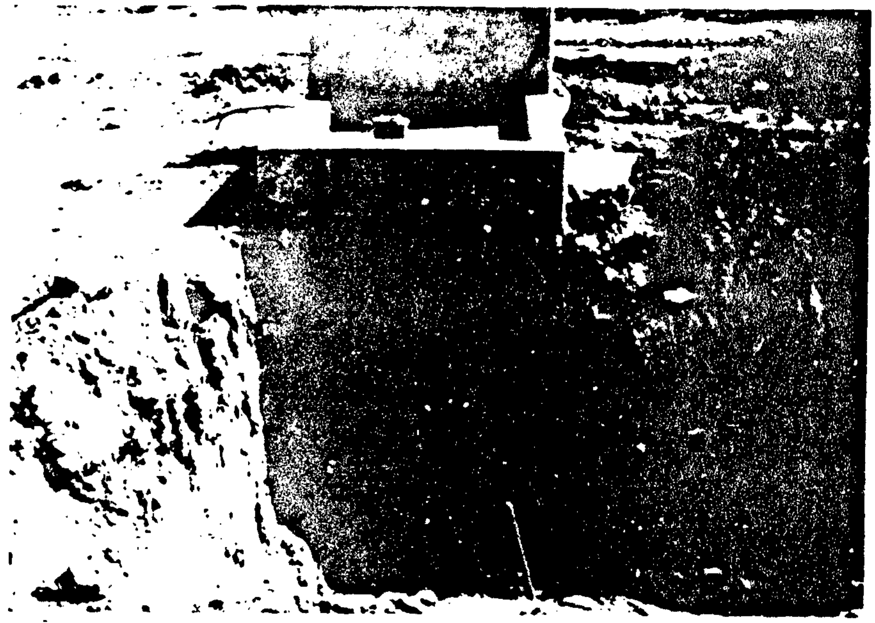


PHOTO 9 - WELL HOUSE WAITING TO BE HOOKED
INTO WATER LINE RECHARGE PHASE II
APRIL 22, 1981

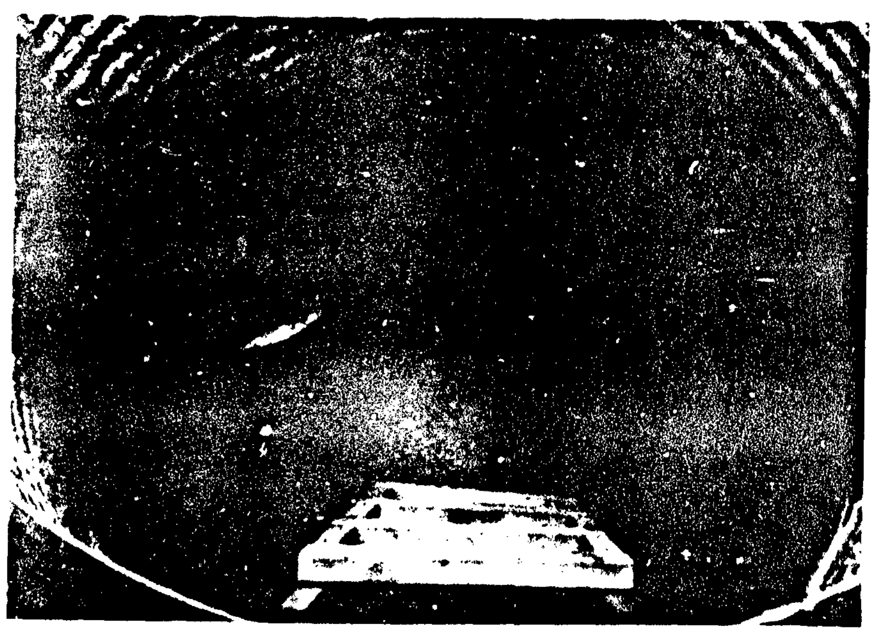


PHOTO 10 - RECHARGE WELL W/ MECHANICAL REMOVED
JUNE 18, 1981

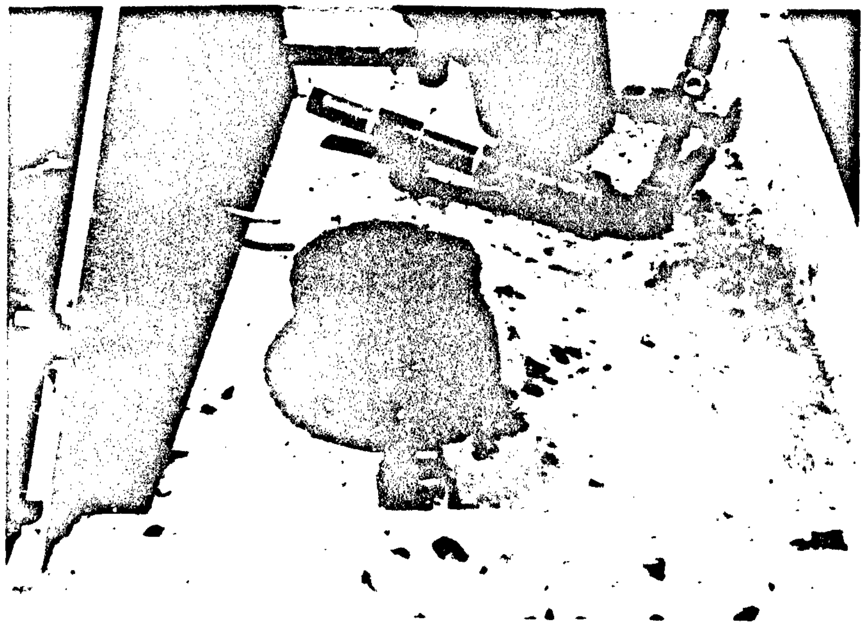


PHOTO 11 - NEAT SEAL GROUT ON DS DEWATER WELLS
AUGUST 7, 1981

PHOTO 12 - PLACING GRAVEL PACK
FEBRUARY 1981

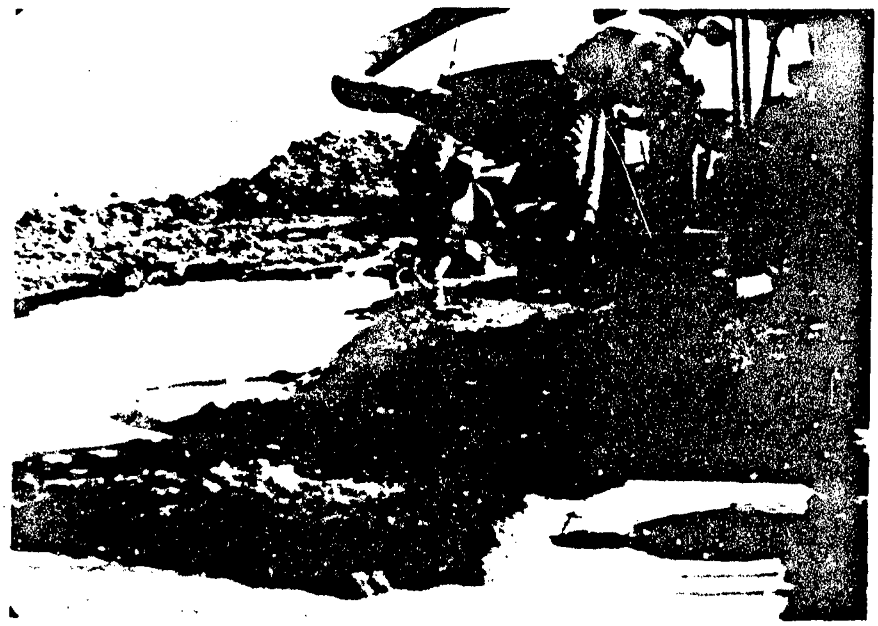


PHOTO 13 - SAMPLE TAKING REVERSE ROTARY RIG
MARCH 1981

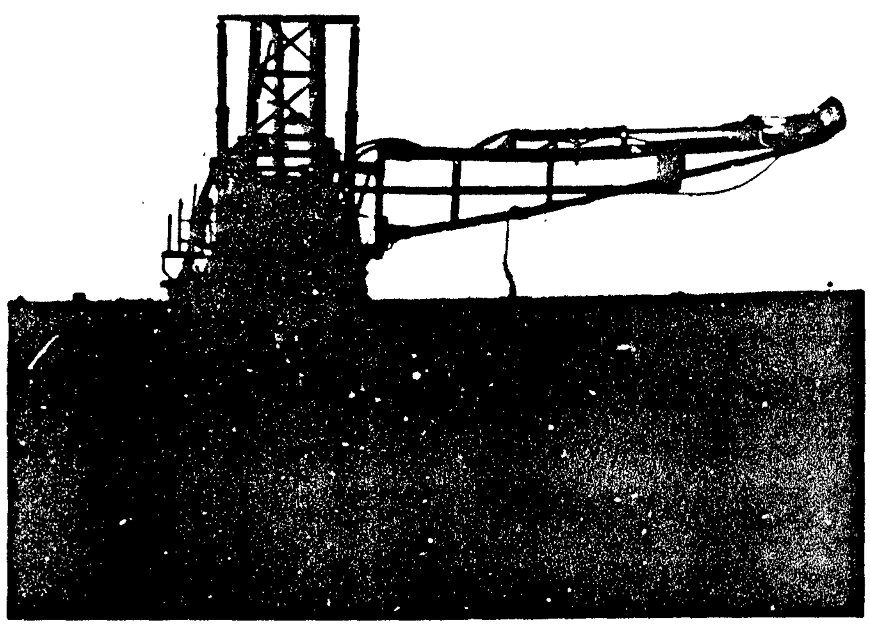


PHOTO 14 - DEVELOPING PROCESS
MARCH 1981

PHOTO 15 - COBBLES FROM HOLE DW 22
APRIL 23, 1981

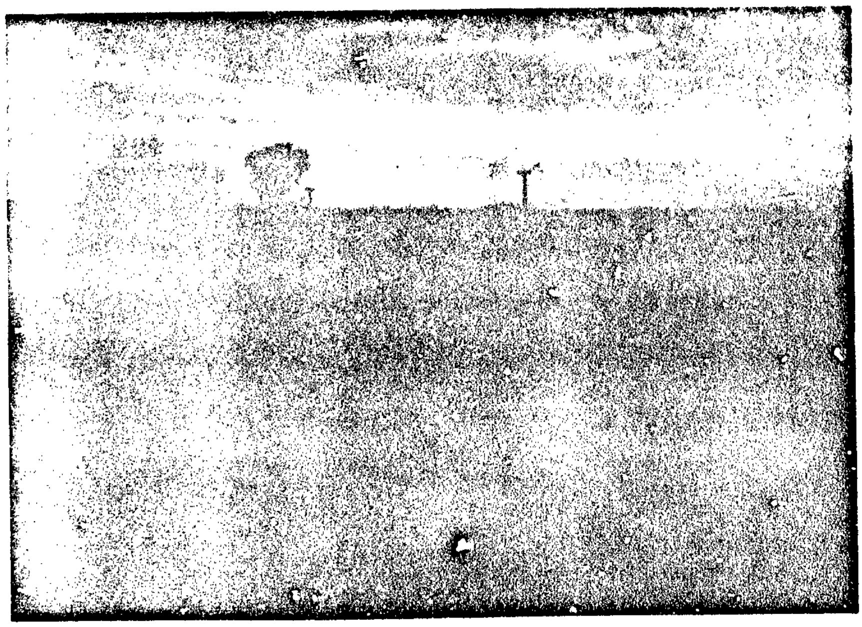


PHOTO 16 - NORTH END OF 1ST CREEK & LEVEE
APRIL 23, 1981

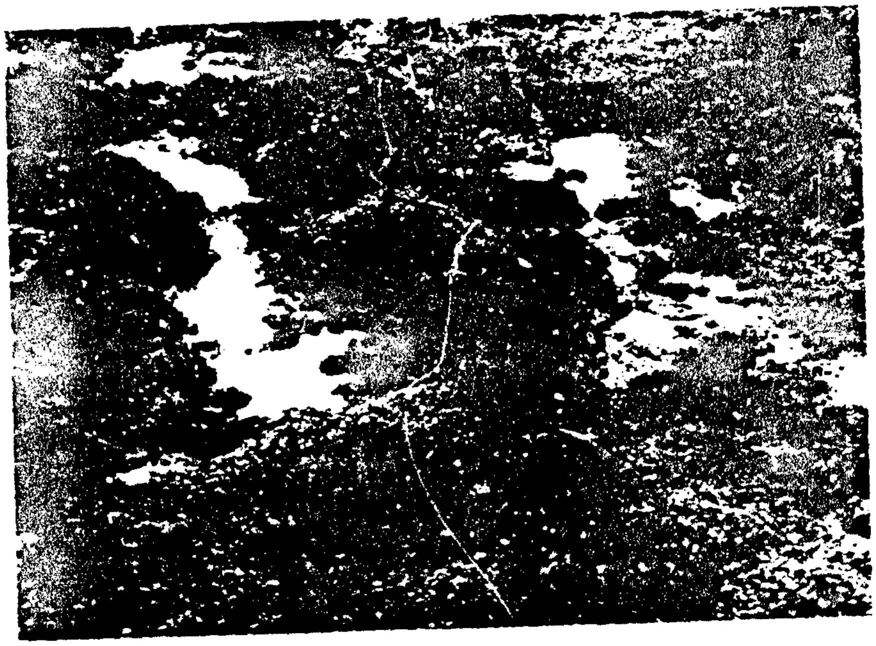


PHOTO 17 - EXPLOSIVE CHARGE LINE FOR 2ND BLAST
JULY 15, 1981

PHOTO 18 - LOADING EXPLOSIVE
JULY 15, 1981

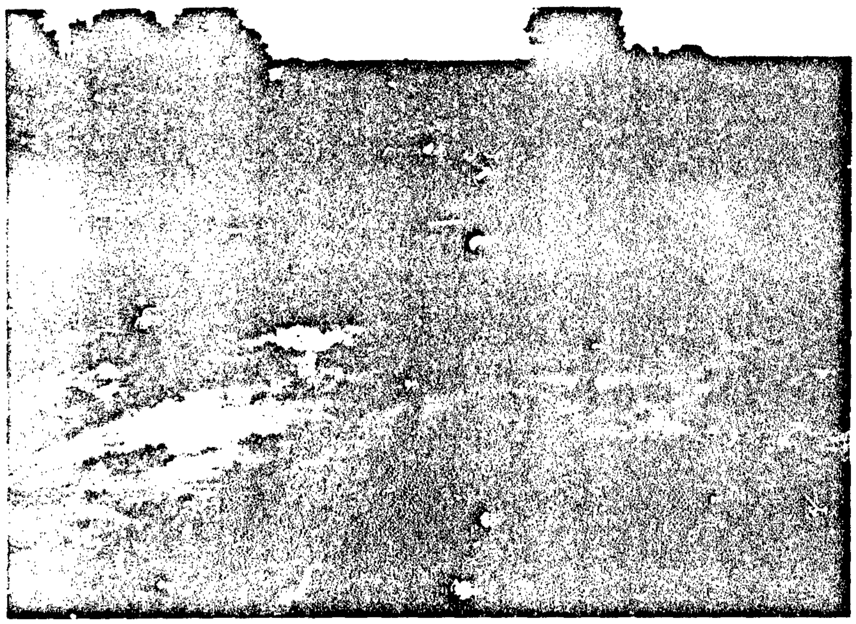


PHOTO 19 - GROUND WATER BUBBLING UP AFTER 1ST BLAST
JULY 13, 1981

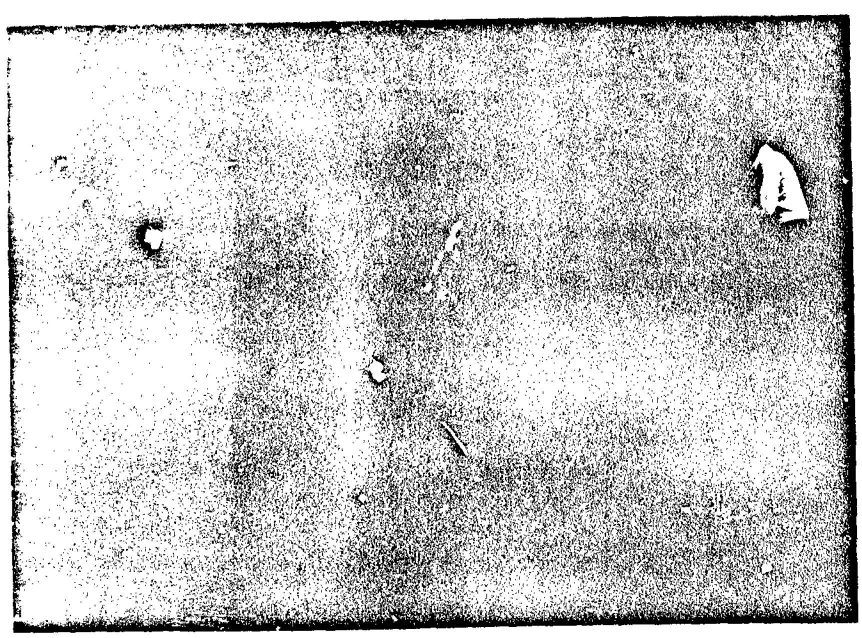


PHOTO 20 - 20 - STICK CHARGE PLACED ON SANDSTONE
AUGUST 11, 1981

PHOTO 21 - GROUTING PIEZOMETER
APRIL 1, 1981

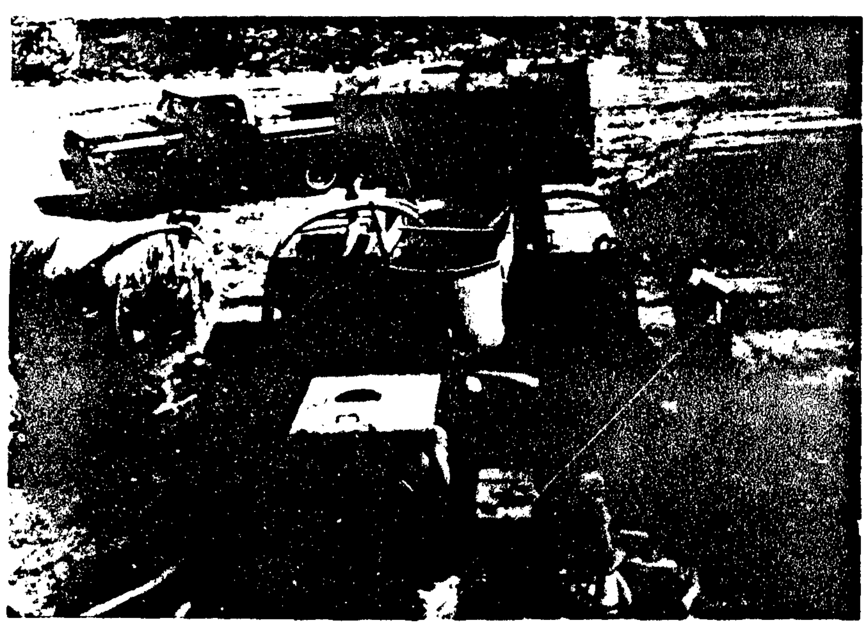


PHOTO 22 - GROUTING OPERATION FOR CONDUCTOR PIPE

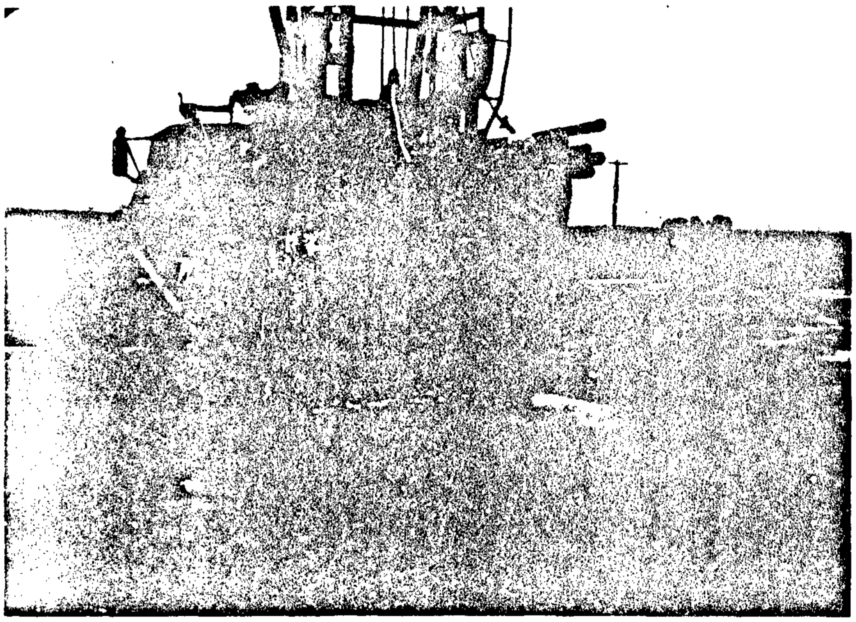


PHOTO 23 - USING FOAM TO DRILL DENVER SANDS
DEWATER WELL W/ AIR ROTARY RIG
JUNE 24, 1981

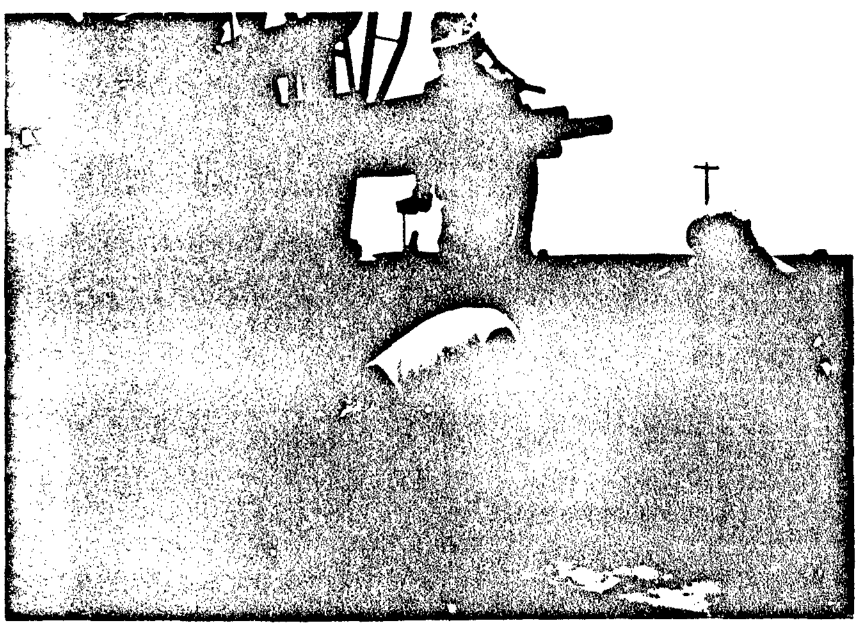


PHOTO 24 - PORT-A-DRILL, CUTTINGS IN STRAINER
JUNE 18, 1981

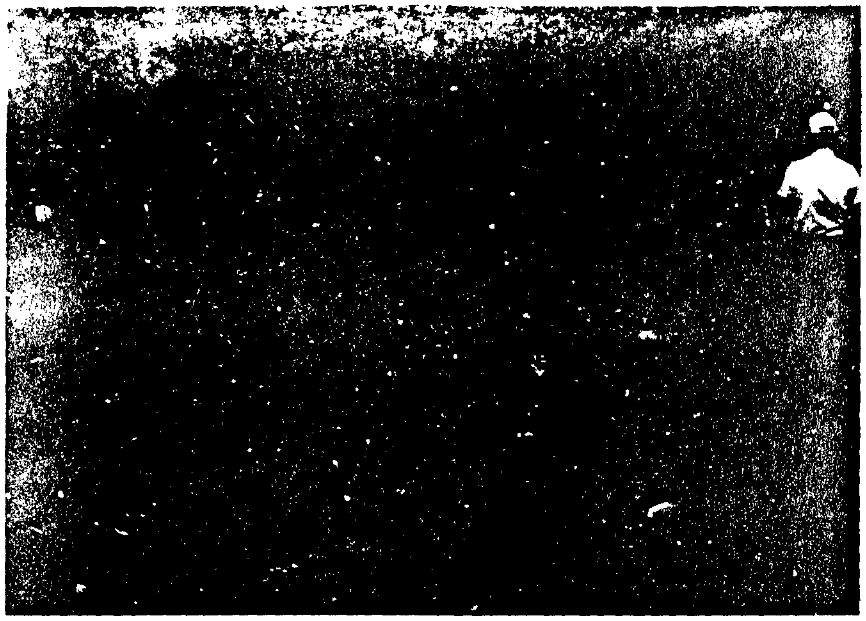


PHOTO 25 - LOOKING WEST AT TRENCH KEY ACROSS CREEK
JULY 22, 1981

PHOTO 26 - GRADING SLOPE TO PROPER ANGLE AT WEST END
JUNE 26, 1981

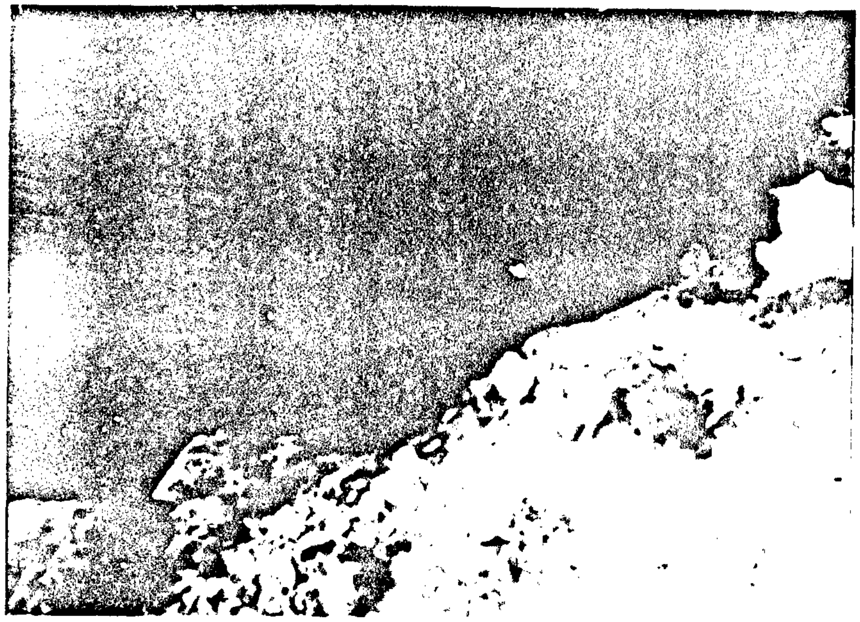


PHOTO 27 - GROUND WATER REACHED IN PHASE II BEGINNING CUT
MAY 11, 1981

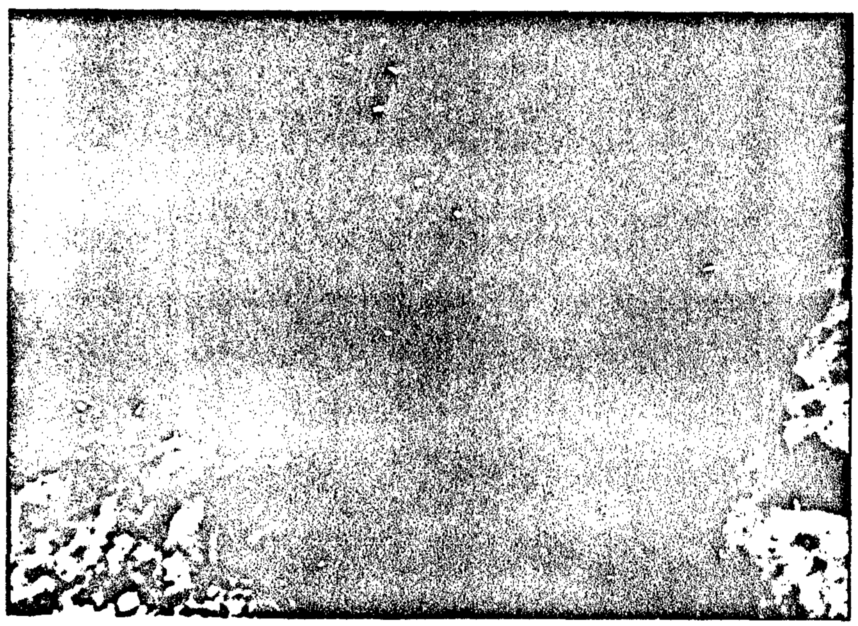


PHOTO 28 - ADDING SLURRY TO STABILIZE PHASE II CUT
MAY 11, 1981

PHOTO 29 - ROCK STUCK IN CENTER OF DRILLING BIT
MAY 24, 1981

PHOTO 30 - PEBBLE AND ROCK DEBRIS FROM RECHARGE WELL
May 24, 1981

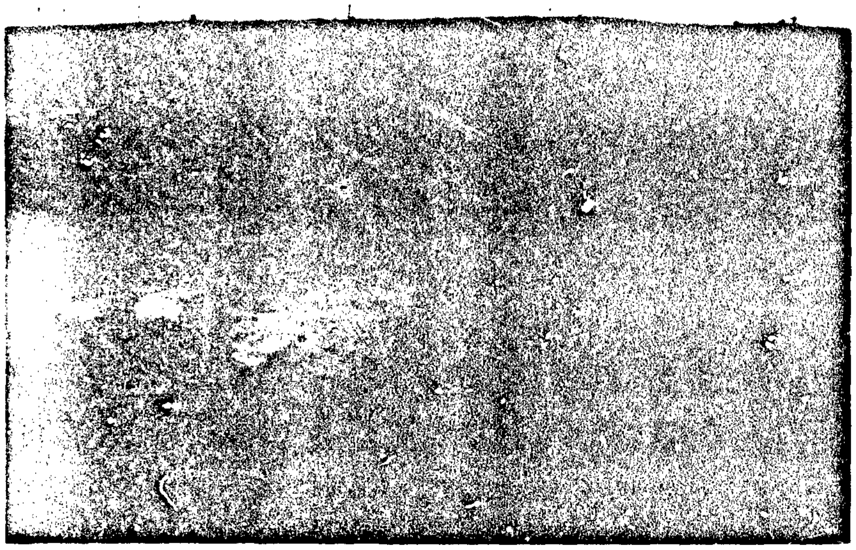


PHOTO 31 - BACKFILL MIXING. ADDING SOME SAND, PHASE III.
AUGUST 6, 1981

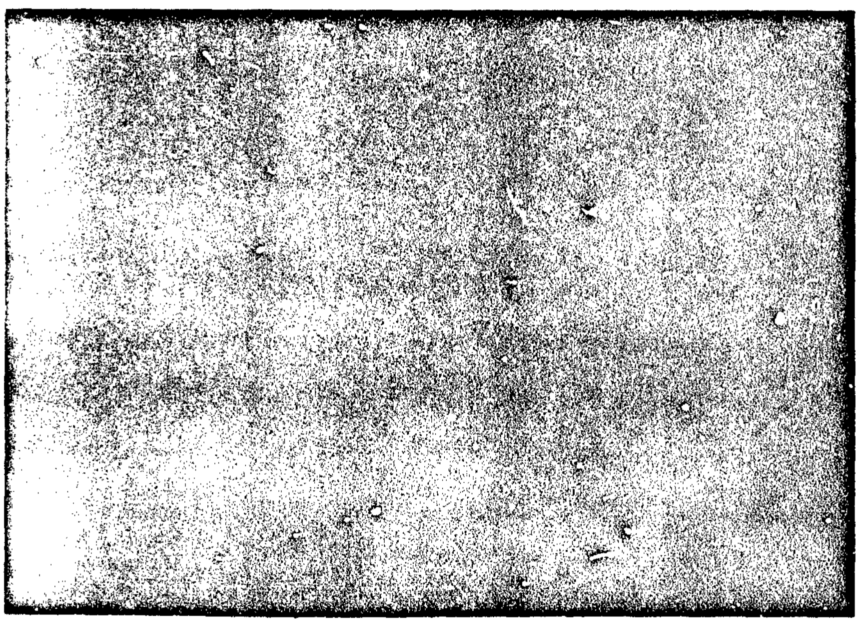


PHOTO 32 - SLURRY MIXING
APRIL 9, 1981

PHOTO 33 - MIXING OF 2ND SLURRY POND
APRIL 10, 1981

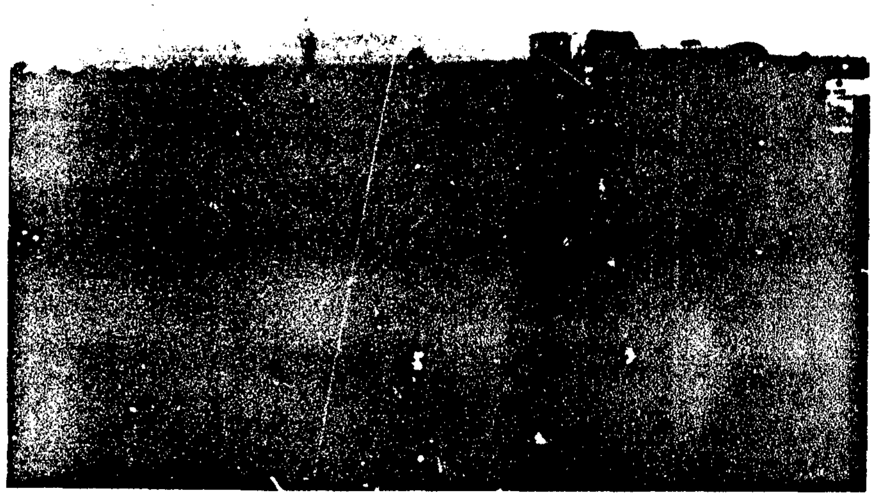


PHOTO 34 - SLURRY MIXING
APRIL 10, 1981

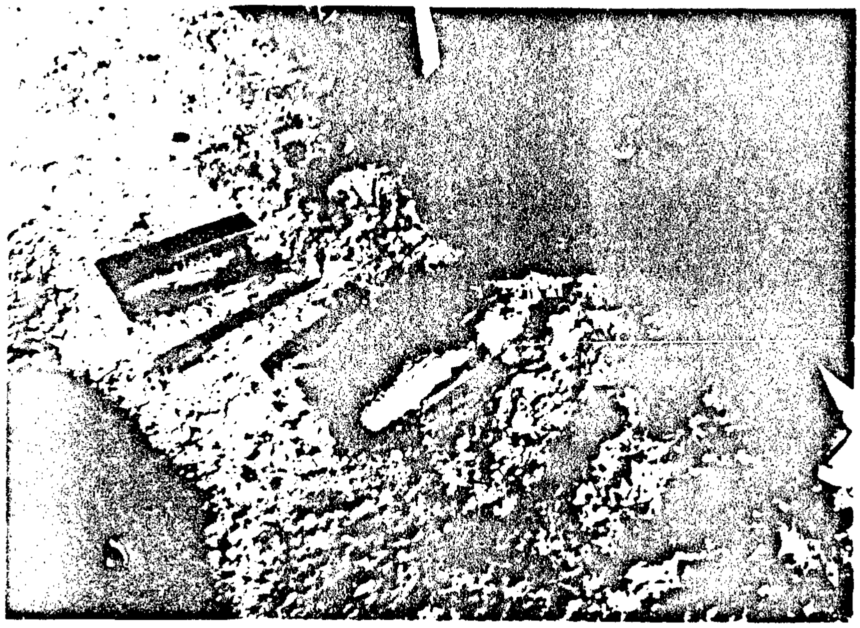


PHOTO 35 - BEDROCK CORE
JUNE 22, 1981

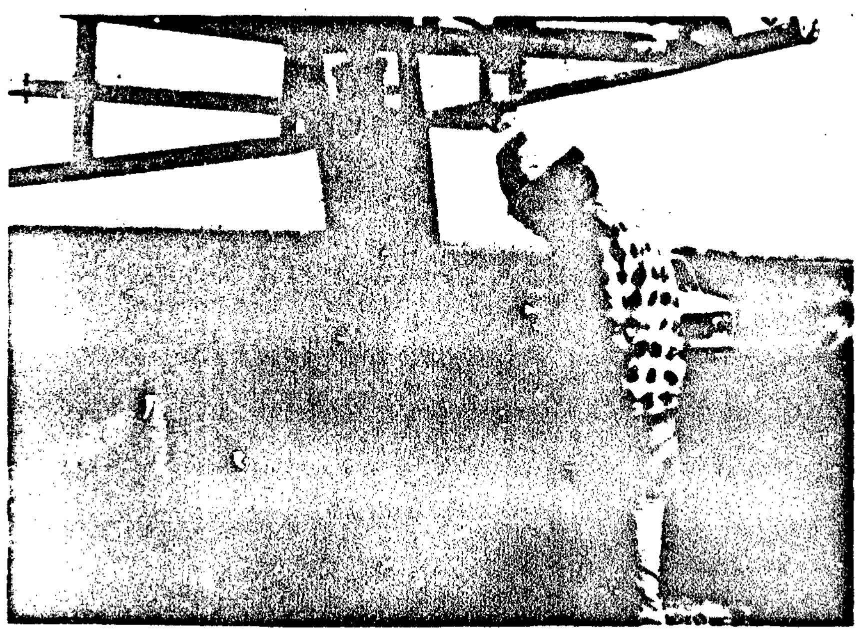


PHOTO 36 - BUCKET BIT FOR BW WELLS
FEBRUARY 1981

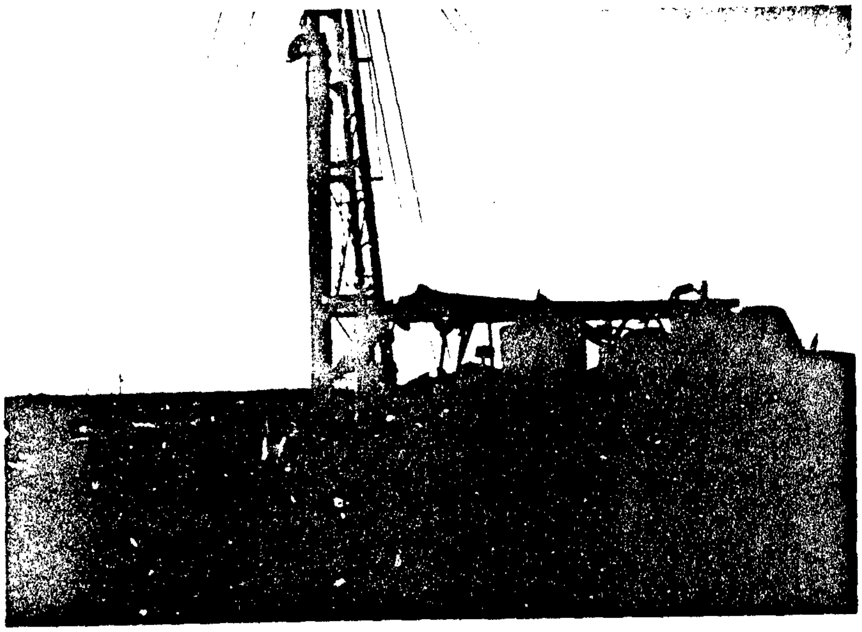


PHOTO 37 - REVERSE ROTARY DRILL BEFORE SETUP
MARCH 1981

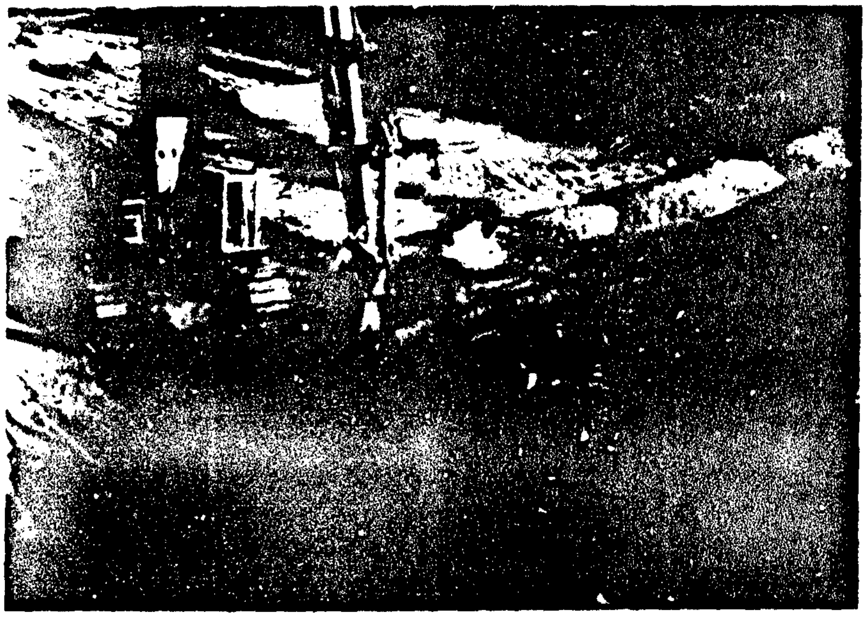


PHOTO 38 - BEGINNING EAST TRENCH APPROX. 50'
EAST OF FIRST MARKER
JUNE 19, 1981

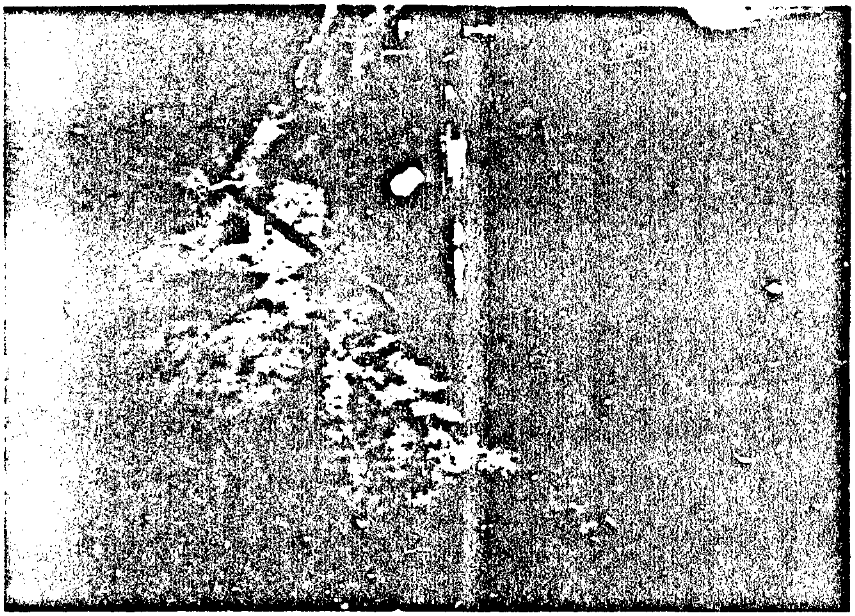


PHOTO 39 - ADDING SLURRY TO TRENCH;
TRYING TO KEEP WITHIN 2' OF GROUND LEVEL
JUNE 16, 1981

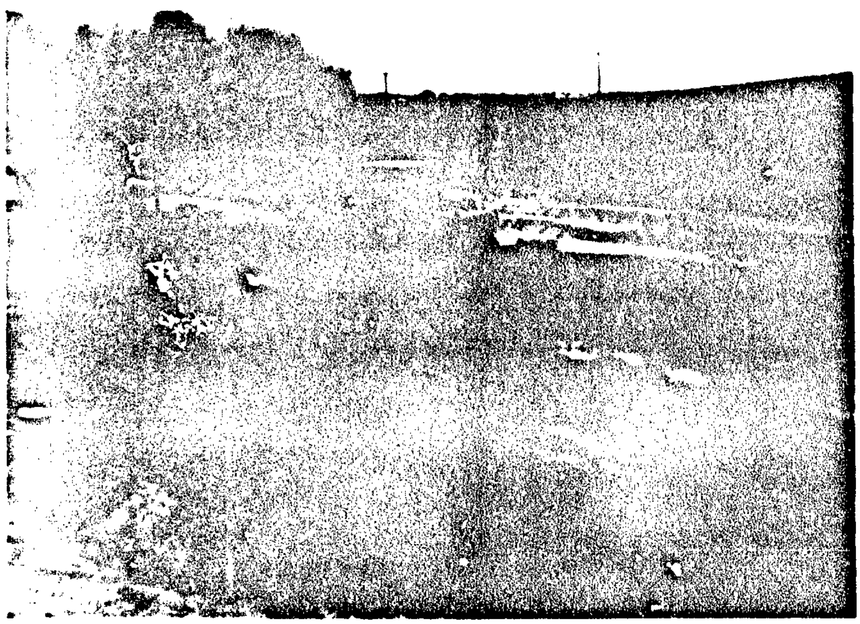


PHOTO 40 - LINK BELT AT ABOUT 15' DOWN IN TRENCH
JUNE 18, 1981

PHOTO 41 - D8K DOZER WORKING HILL FOR CAP MATERIAL
JUNE 17, 1981

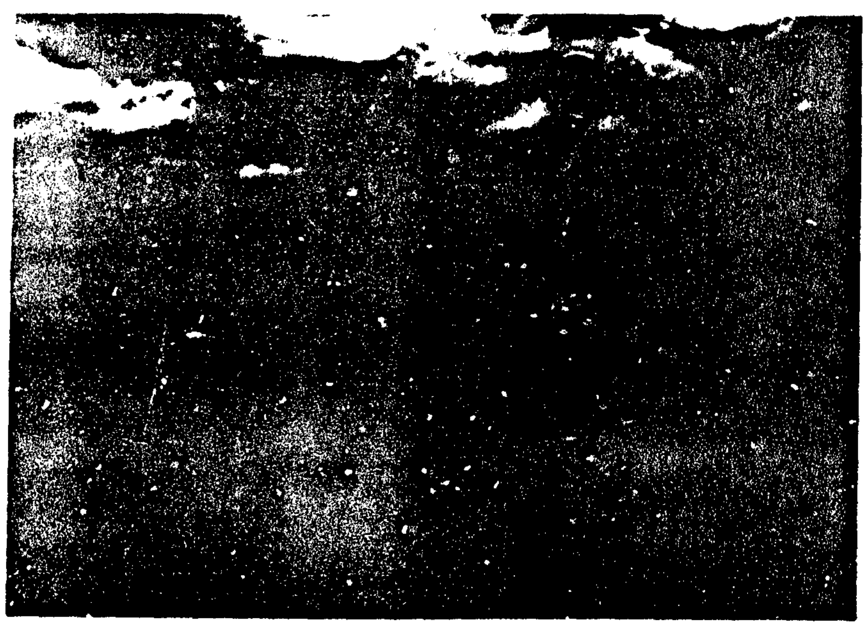


PHOTO 42 - LOOKING EAST AT HILL CUT,
FIRST CREEK IN FOREGROUND
JULY 6, 1981

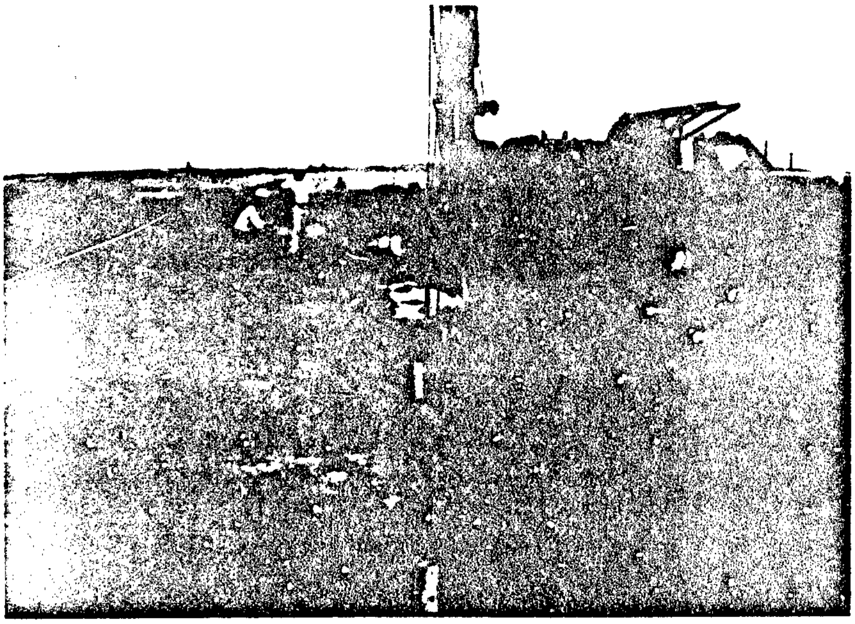


PHOTO 43 - BLAST HOLE LINE LOOKING EAST
JULY 27, 1981

PHOTO 44 - BACKHOE USED FOR SLURRY TRENCH. MAXIMUM DEPTH 41'
APRIL 17, 1981

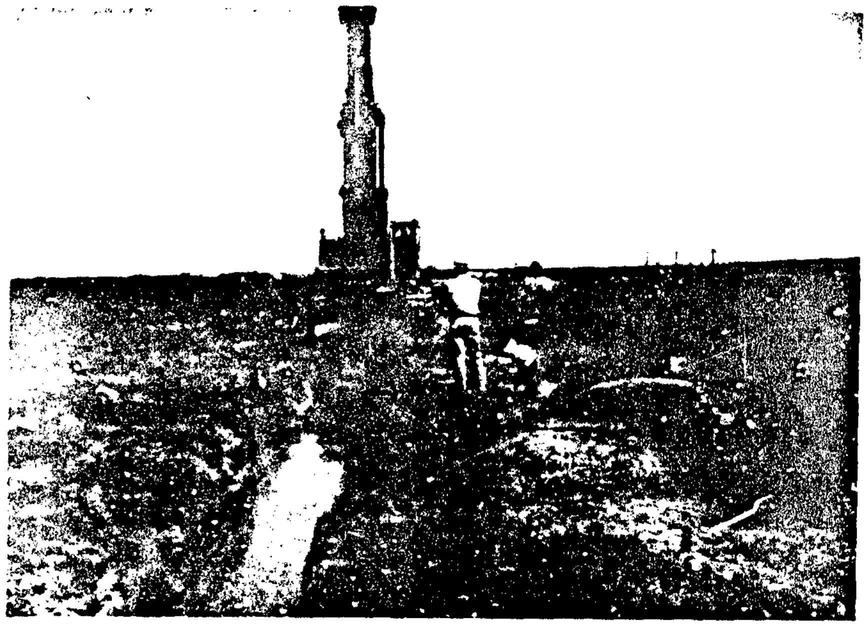


PHOTO 45 - WEST END SLURRY TRENCH
APRIL 16, 1981

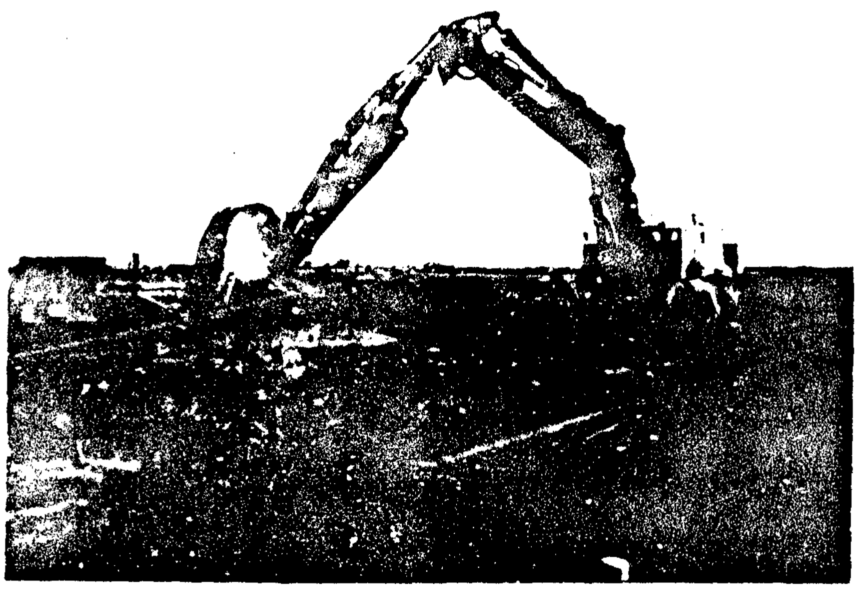


PHOTO 46 - WEST END SLURRY TRENCH W/ DOZER
IN BACKGROUND MIXING BACKFILL
APRIL 16, 1981

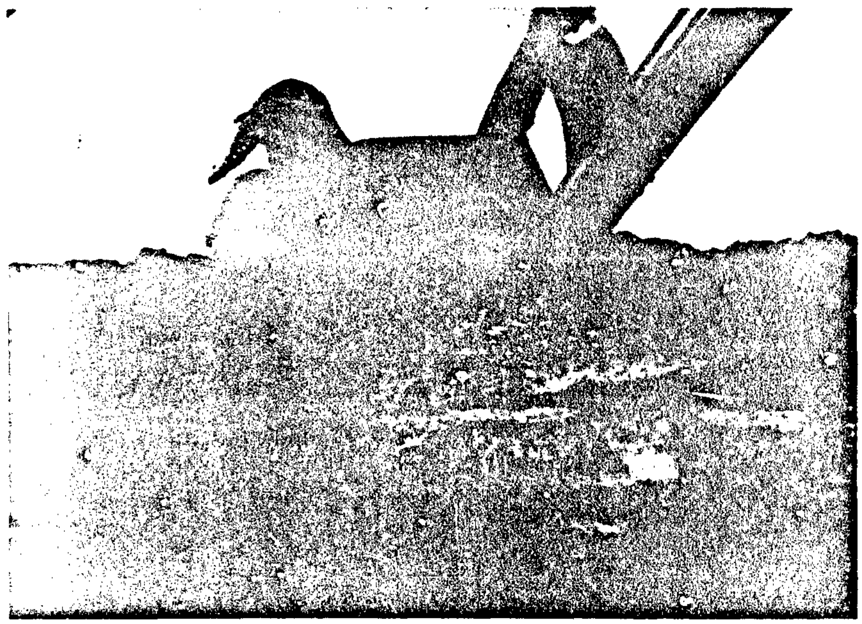


PHOTO 47 - FROST BUCKET
JUNE 6, 1981

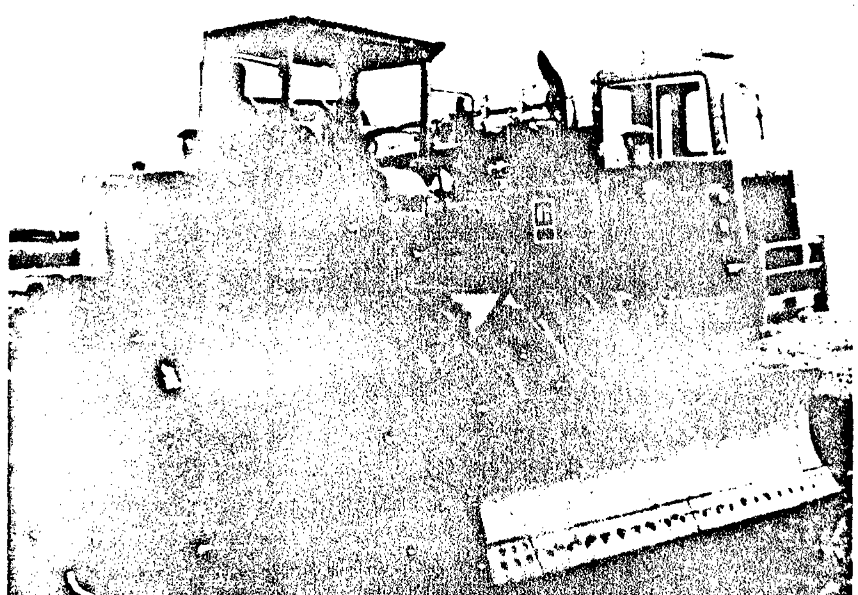


PHOTO 48 - G815 CAT SHEEPS FOOT W/ DOZER BLADE (ECI)
FEBRUARY 23, 1981

PHOTO 49 - 1ST CREW CORING HOLES
ALONG CENTER LINE OF EAST TRENCH
MARCH 1981

PHOTO 50 - D8K - ECI EARTH MOVING
FEBRUARY 23, 1981

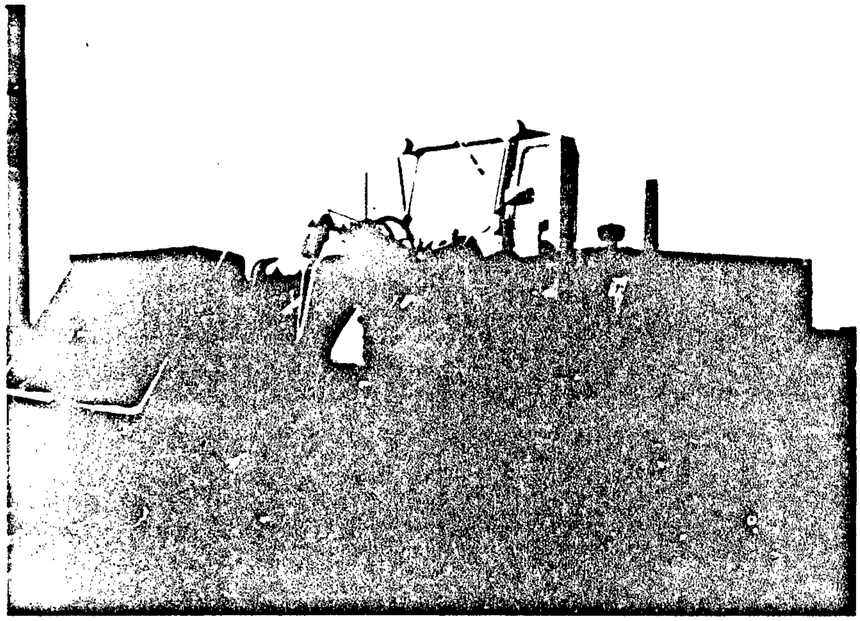


PHOTO 51 - FRONT END LOADER (ECI)
MARCH 1981

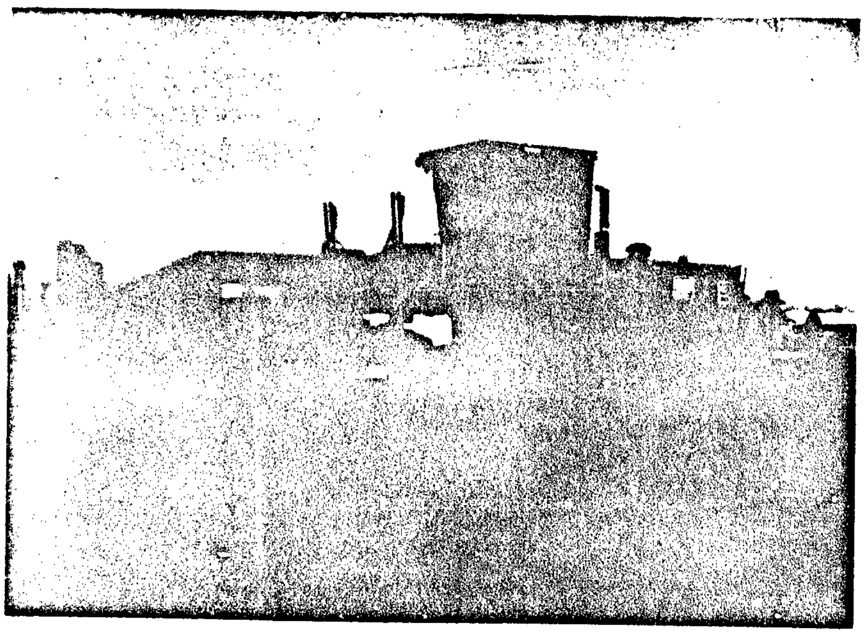
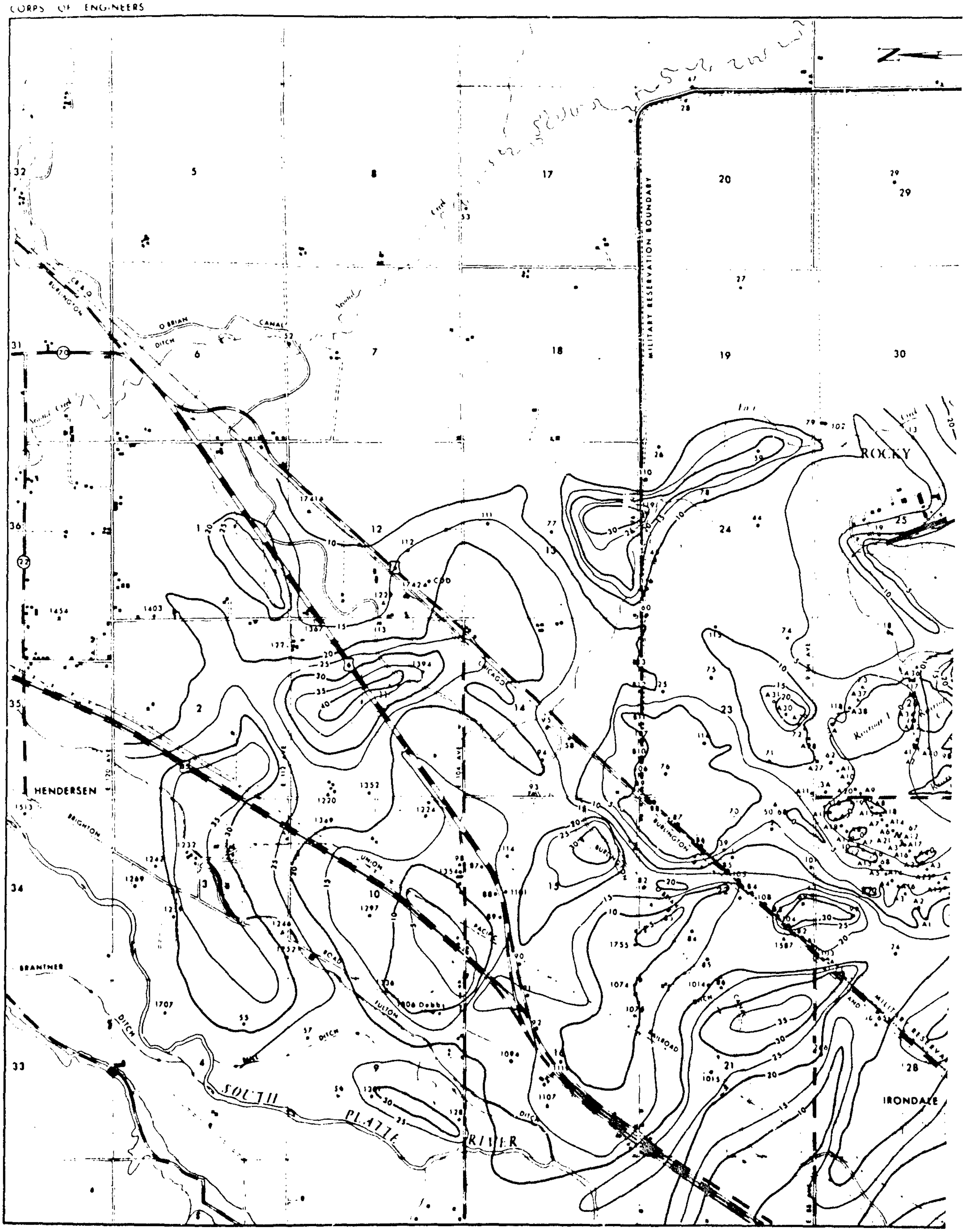


PHOTO 52 - 14G CAT MOTOR GRADER (ECI)
FEBRUARY 23, 1981

PLATES

CORPS OF ENGINEERS



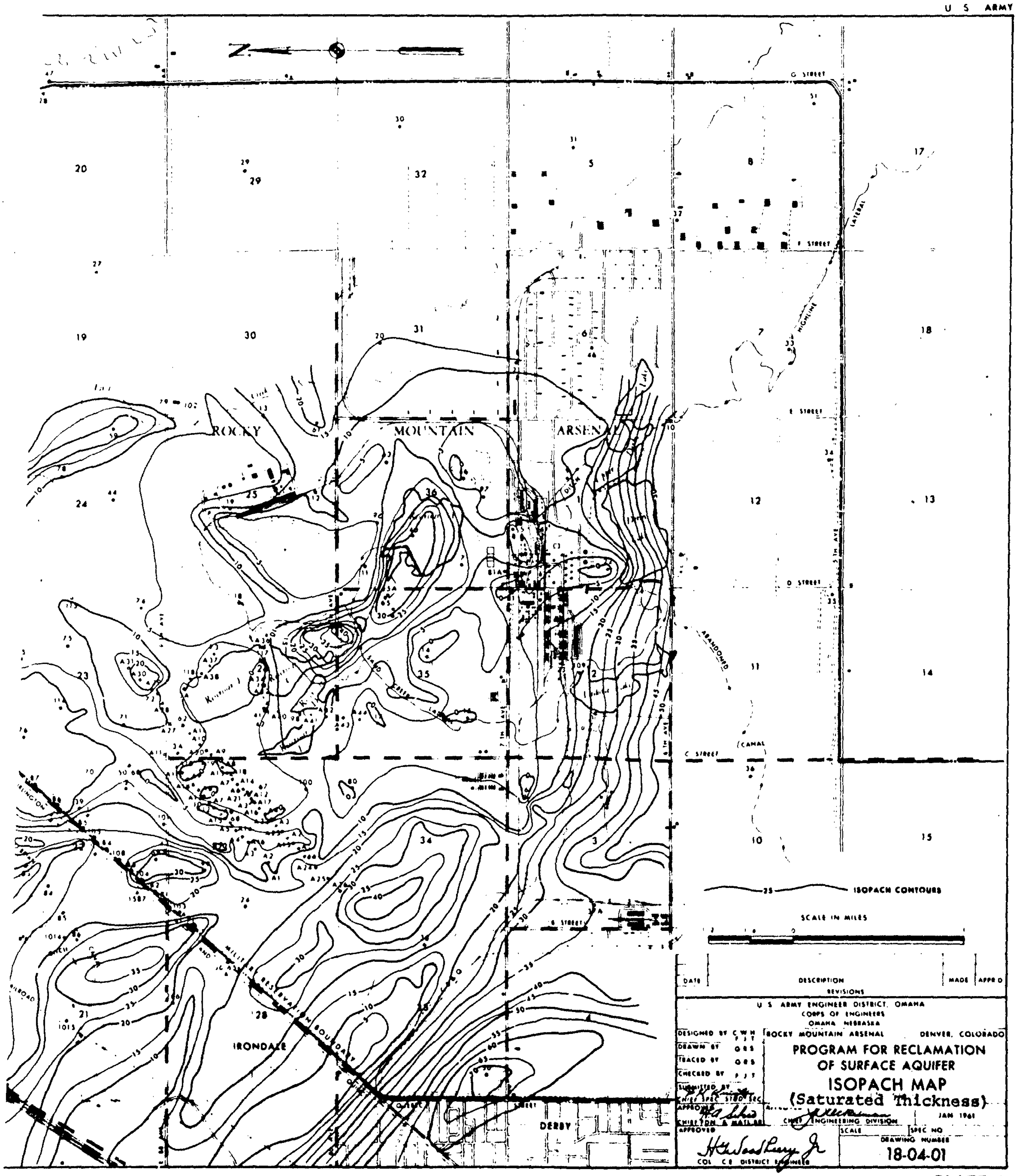
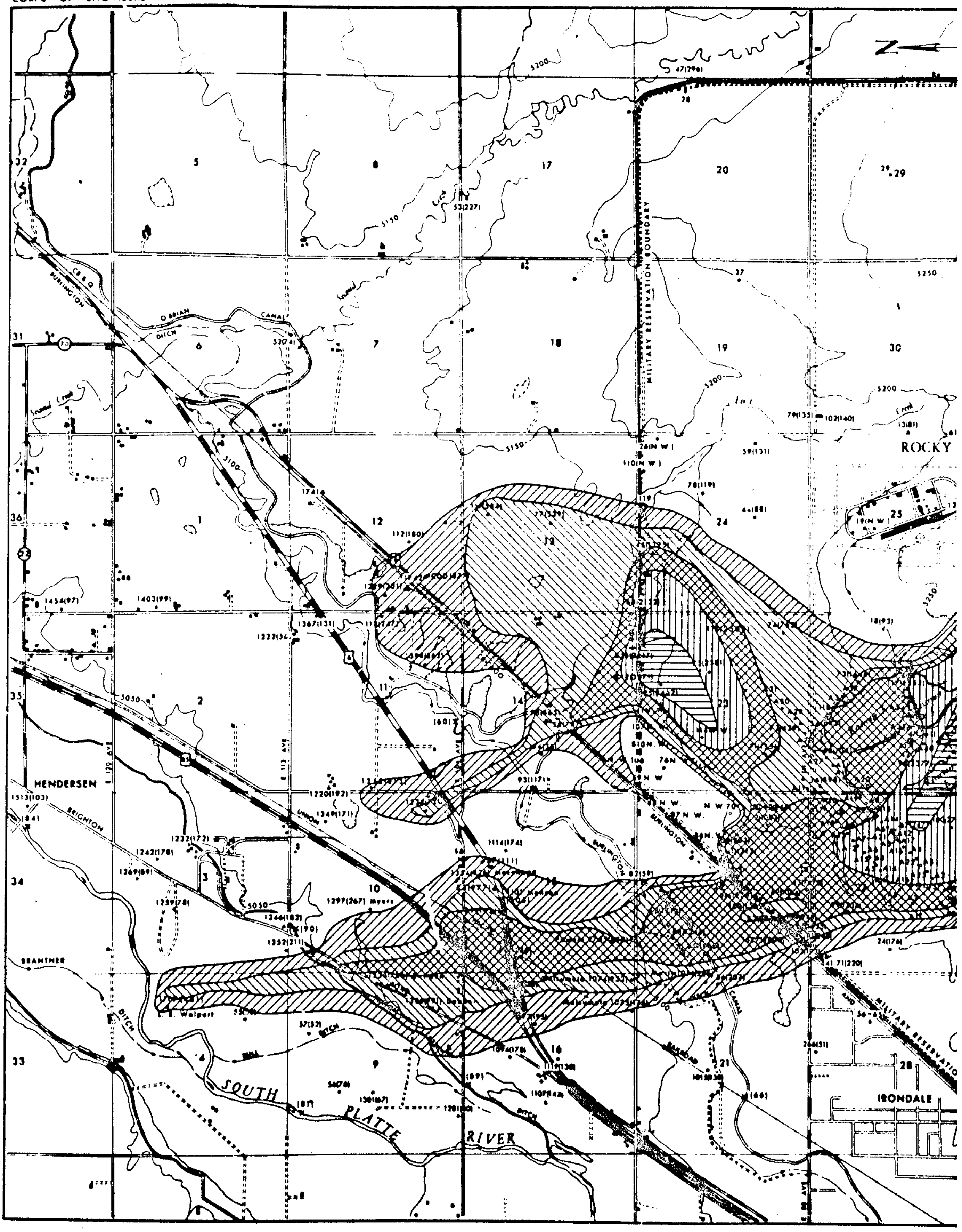

U S ARMY
ROCKY MOUNTAIN ARSENAL
G STREET
F STREET
E STREET
D STREET
C STREET
B STREET
IRONDALE
DERBY
ISOPACH CONTOURS
SCALE IN MILES
DATE
DESCRIPTION
REVISIONS
MADE
APPR'D
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO
PROGRAM FOR RECLAMATION
OF SURFACE AQUIFER
ISOPACH MAP
(Saturated Thickness)
JAN 1961
CHIEF ENGINEERING DIVISION
COL CE DISTRICT ENGINEER
DRAWING NUMBER
18-04-01

PLATE 1.

CORPS OF ENG'NEERS



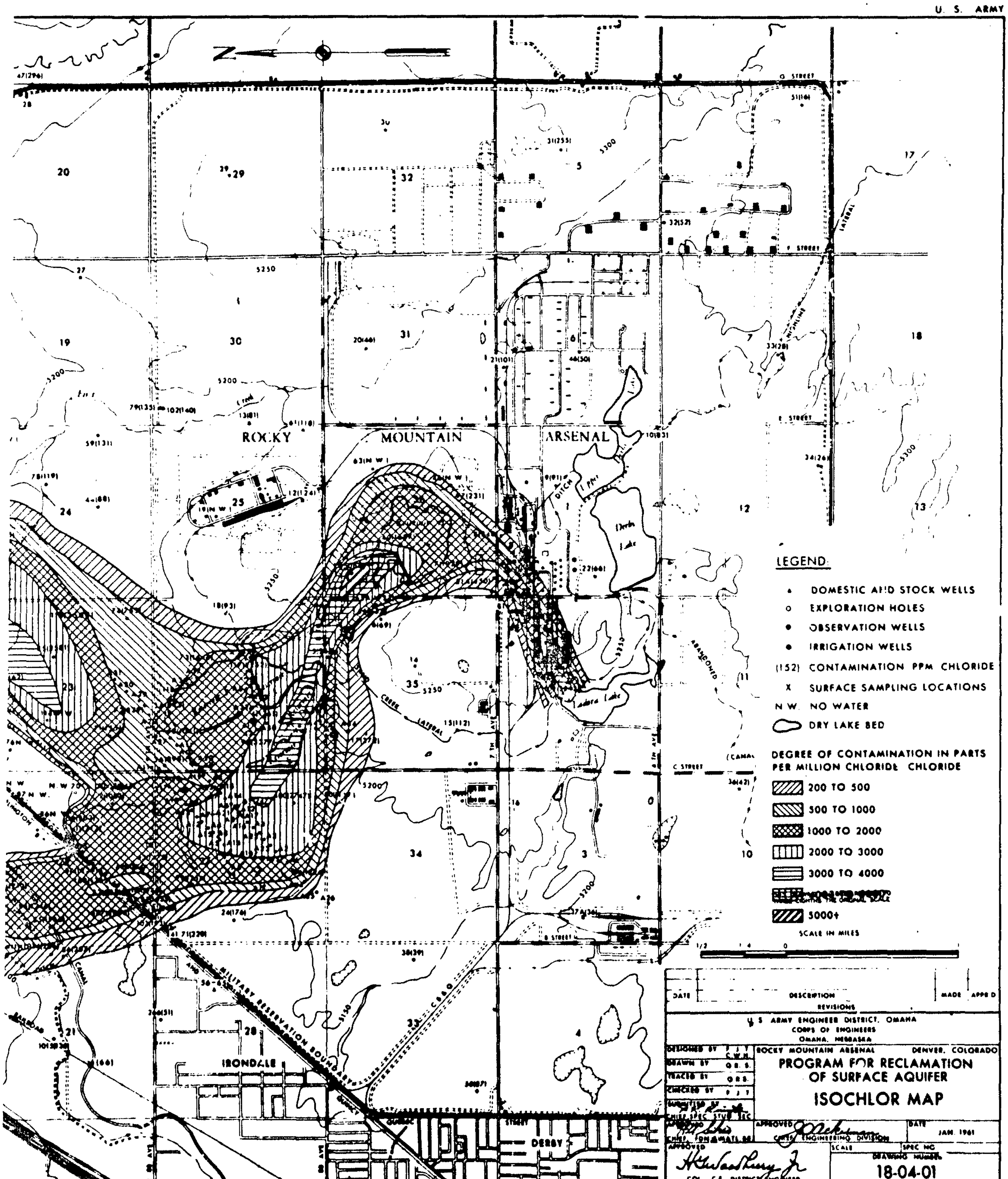
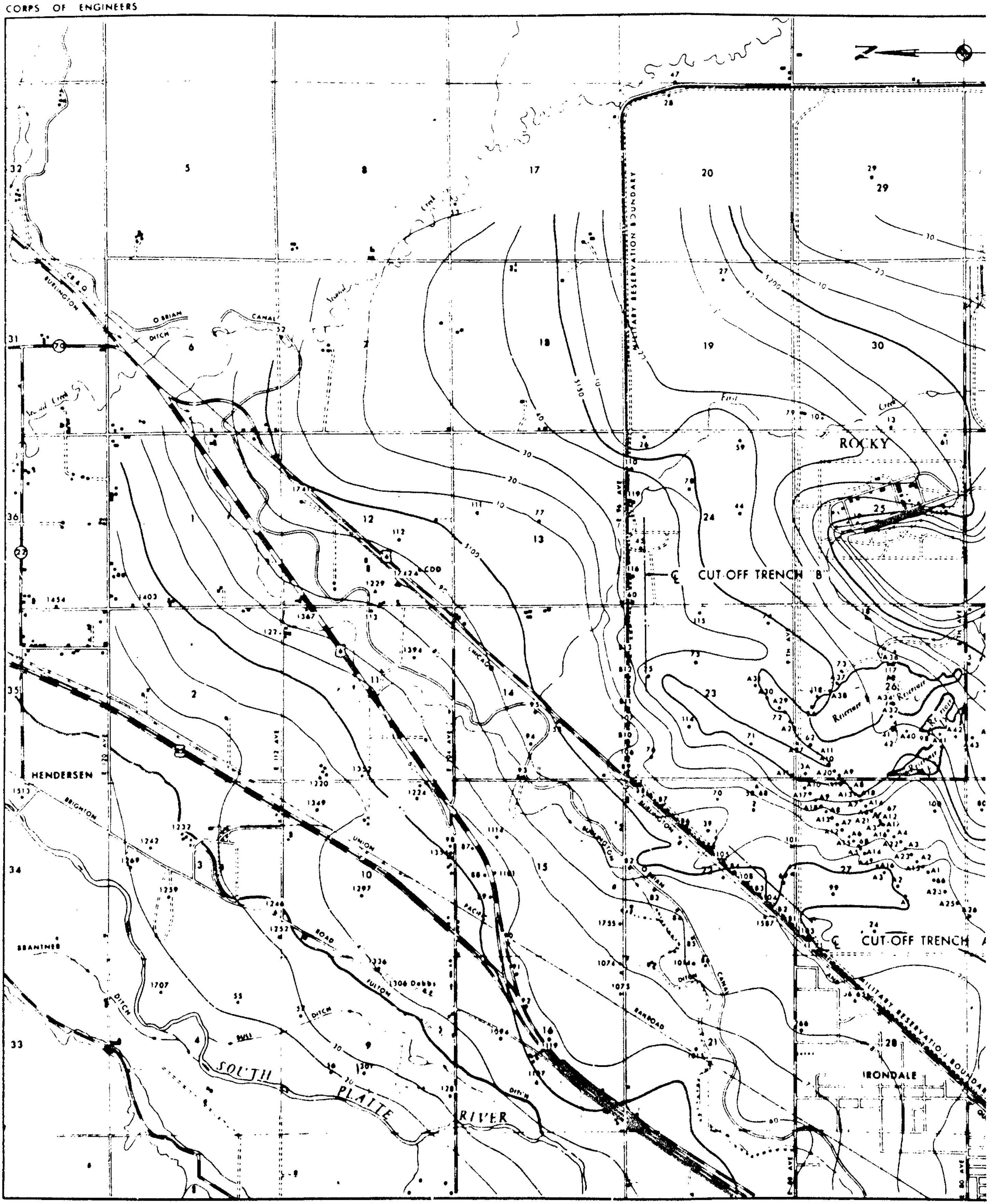

U. S. ARMY
ROCKY
MOUNTAIN
ARSENAL
LEGEND
DOMESTIC AND STOCK WELLS
EXPLORATION HOLES
OBSERVATION WELLS
IRRIGATION WELLS
(152) CONTAMINATION PPM CHLORIDE
X SURFACE SAMPLING LOCATIONS
N.W. NO WATER
DRY LAKE BED
DEGREE OF CONTAMINATION IN PARTS PER MILLION CHLORIDE CHLORIDE
200 TO 500
500 TO 1000
1000 TO 2000
2000 TO 3000
3000 TO 4000
5000+
SCALE IN MILES
G STREET
F STREET
E STREET
C STREET
B STREET
DERBY
IRONDALE
MILITARY RESERVATION BOUNDARY
Derby Lake
DATE
DESCRIPTION
REVISIONS
MADE
APP'D
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO
PROGRAM FOR RECLAMATION
OF SURFACE AQUIFER
ISOCHLOR MAP
DESIGNED BY
DRAWN BY
TRACED BY
CHECKED BY
APPROVED
CHIEF, ENGINEERING DIVISION
DATE
JAN. 1961
SCALE
SPEC NO
DRAWING NUMBER
18-04-01
COL. C.E. DISTRICT ENGINEER

PLATE 2

2

CORPS OF ENGINEERS



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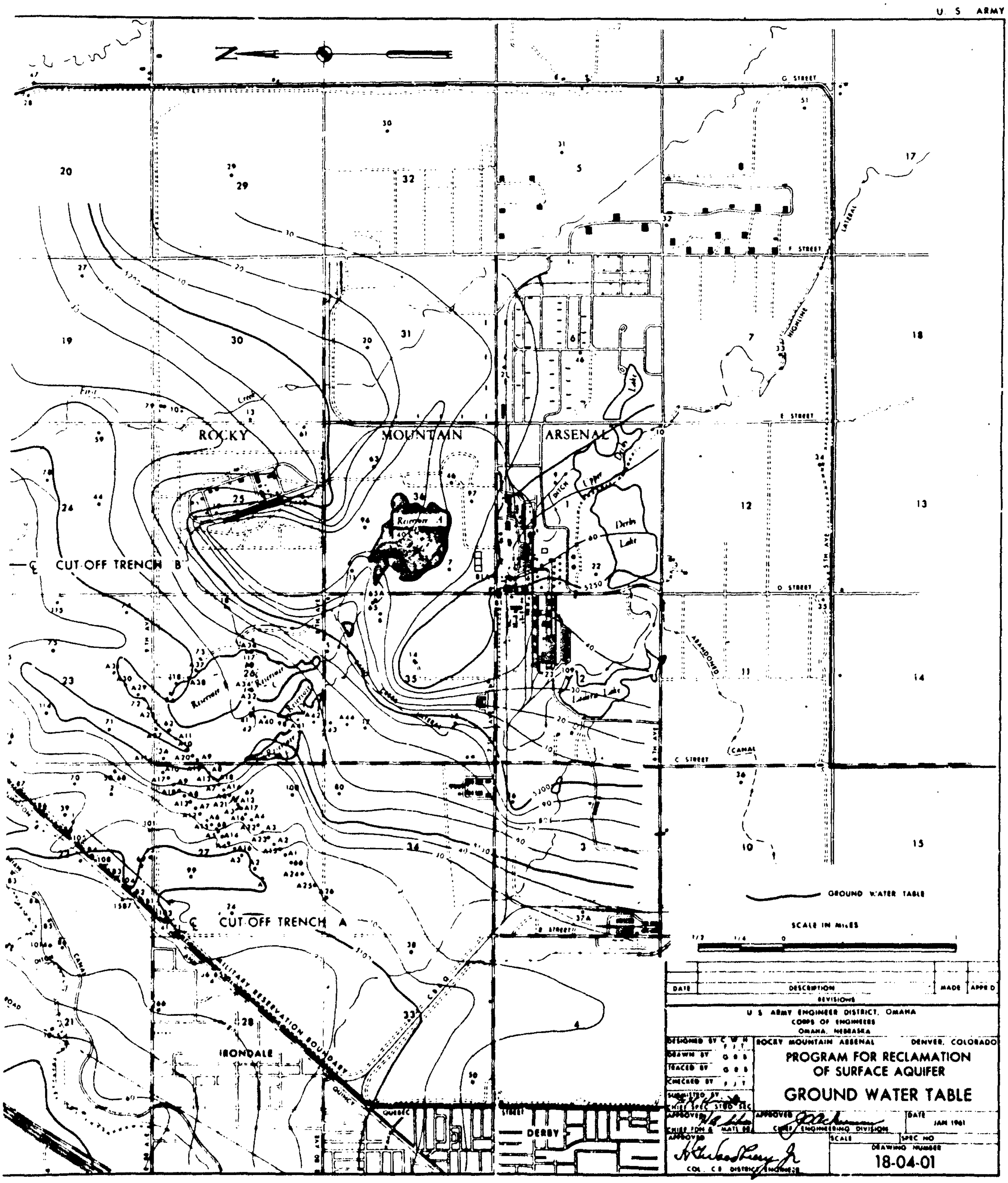
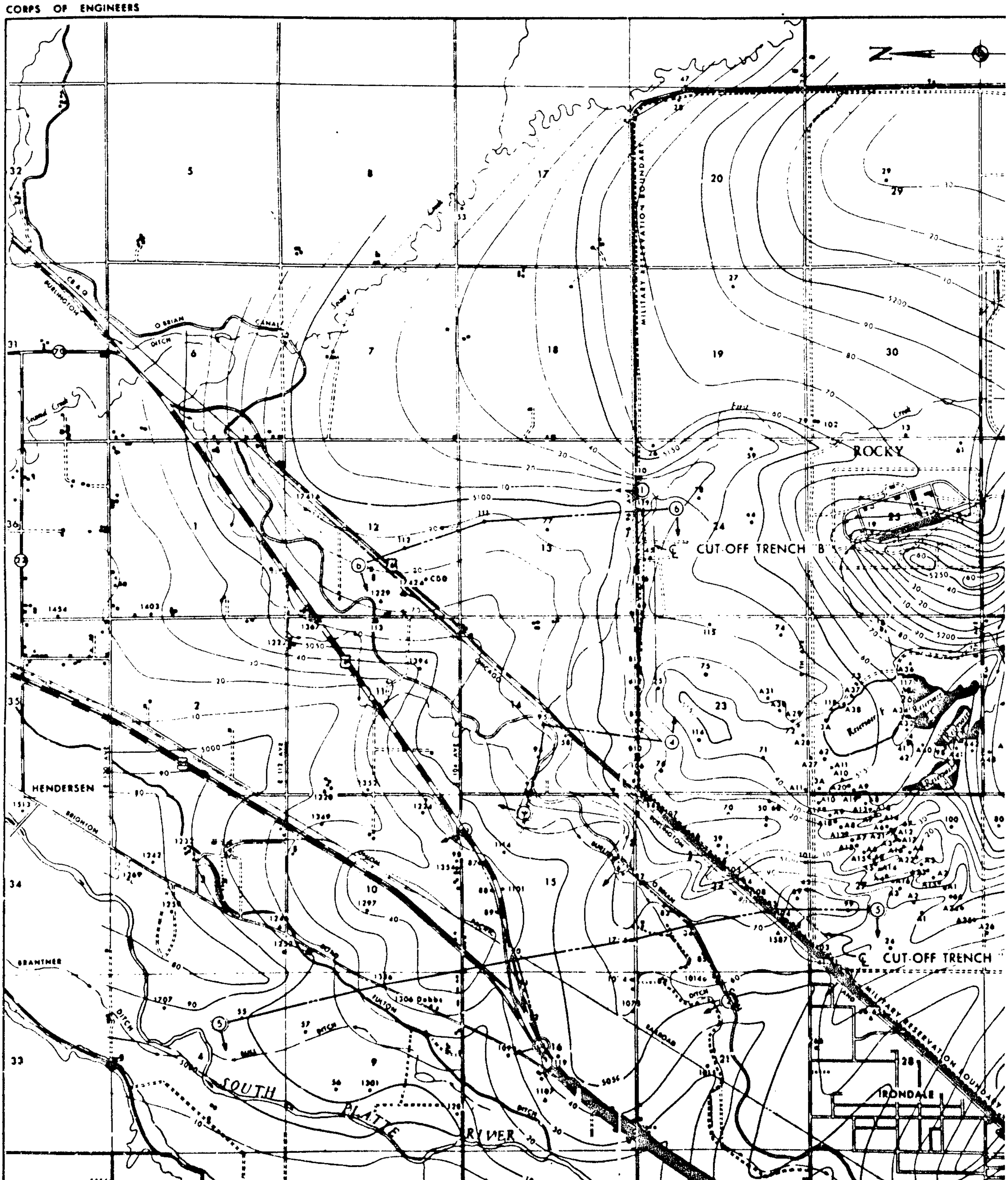

U. S. ARMY
ROCKY MOUNTAIN ARSENAL
CUT-OFF TRENCH B
CUT-OFF TRENCH A
G STREET
F STREET
E STREET
D STREET
C STREET
Reservoir A
Derby Lake
Lake Ladora
Upper Derby Lake
IRONDALE
DERBY
QUEBEC
QUINCY
MILITARY RESERVATION BOUNDARY
ABANDONED
CANAL
HIGHLINE
LATERAL
GROUND WATER TABLE
SCALE IN MILES
DATE
DESCRIPTION
MADE
APPR'D
REVISIONS
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO
PROGRAM FOR RECLAMATION
OF SURFACE AQUIFER
GROUND WATER TABLE
CHIEF, ENGINEERING DIVISION
COL. C E DISTRICT ENGINEER
JAN 1961
DRAWING NUMBER
18-04-01

PLATE 3

CORPS OF ENGINEERS



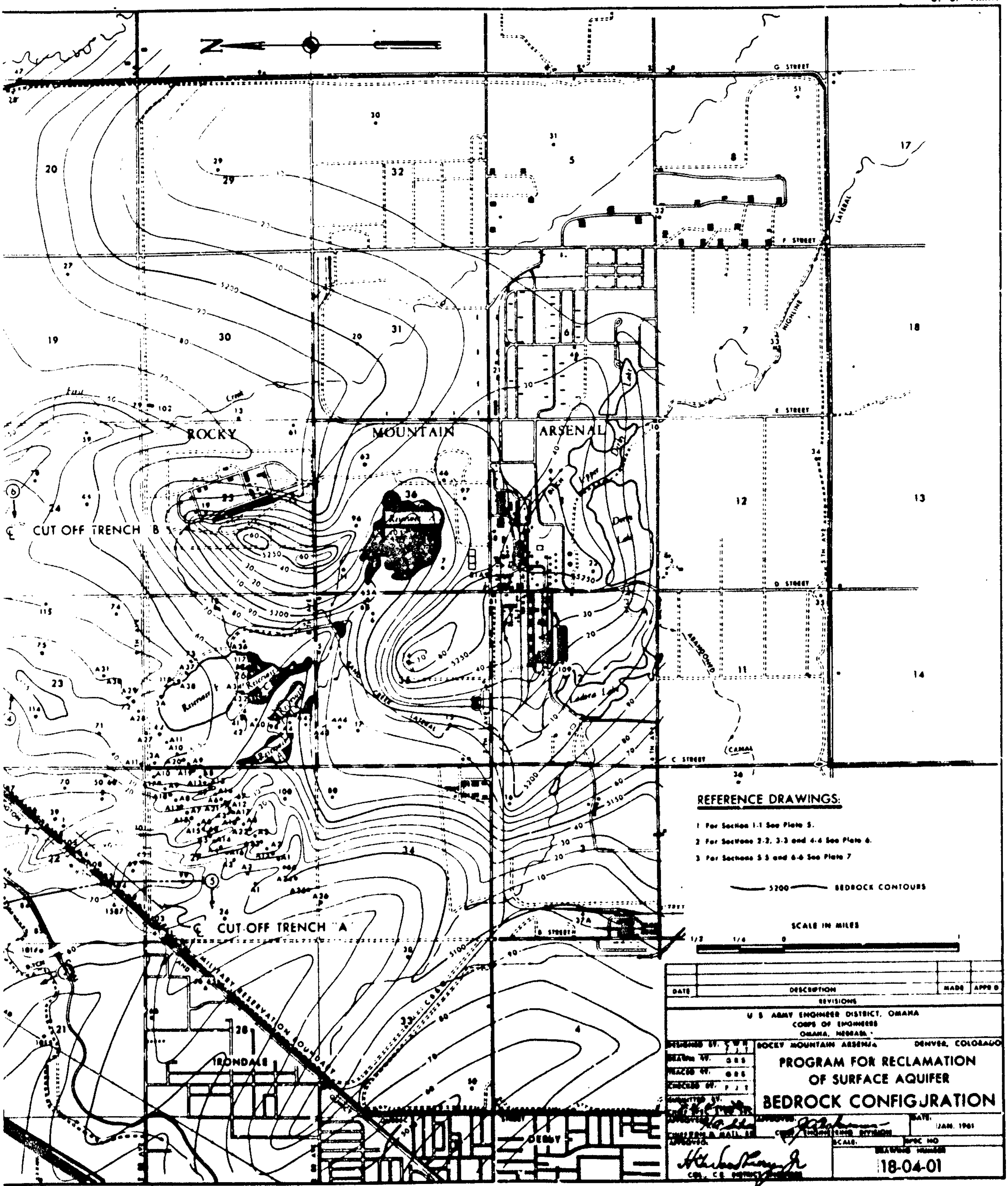
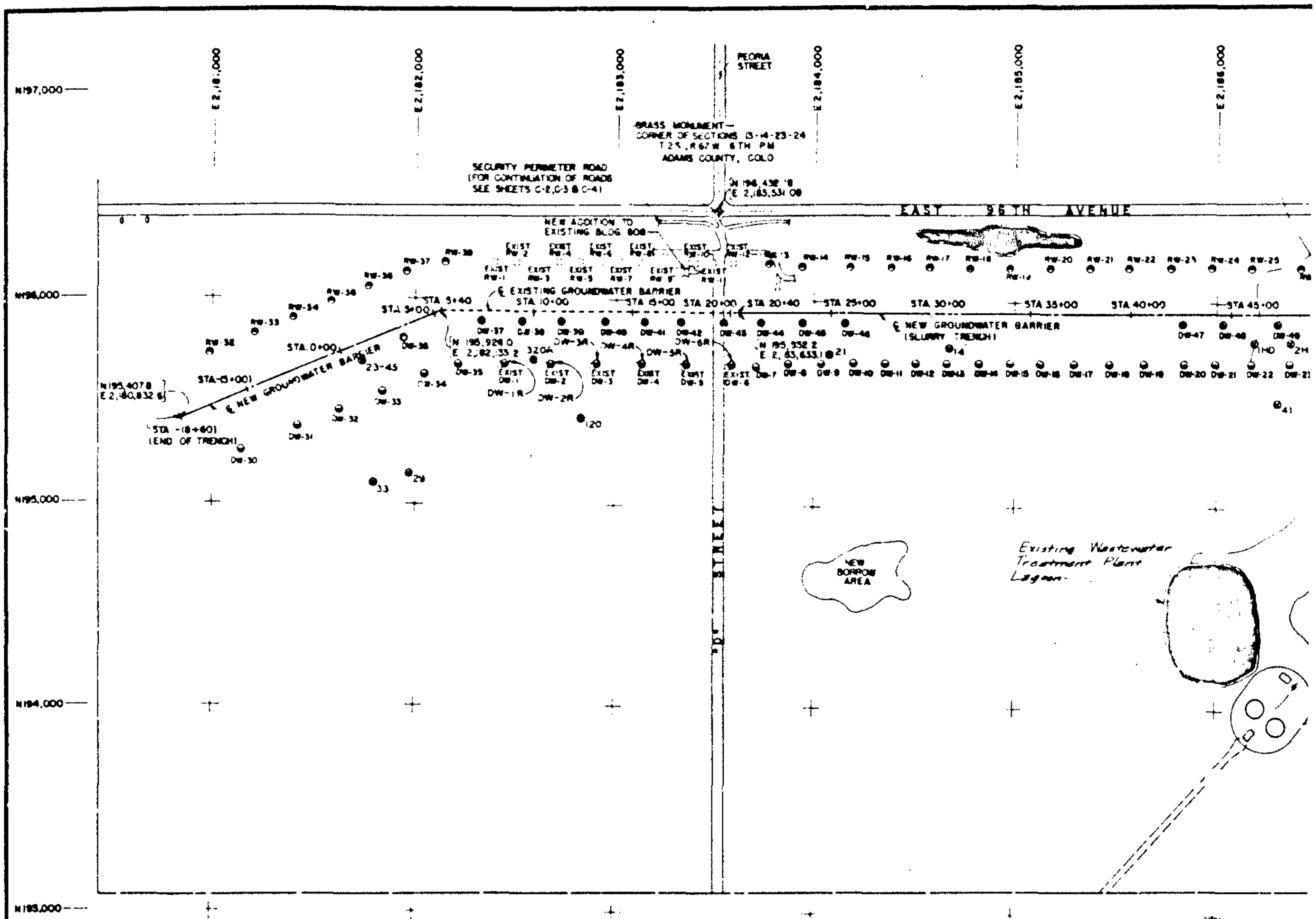

G STREET
F STREET
E STREET
D STREET
C STREET
ROCKY
MOUNTAIN
ARSENAL
CUT OFF TRENCH B
CUT-OFF TRENCH A
IRONDALE
DERBY
REFERENCE DRAWINGS:
1 For Section 1-1 See Plate 5.
2 For Sections 2-2, 3-3 and 4-4 See Plate 6.
3 For Sections 5-5 and 6-6 See Plate 7
5200 BEDROCK CONTOURS
SCALE IN MILES
1/2 1/4 0 1
DATE
DESCRIPTION
MADE
APP'D
REVISIONS
U S ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO
PROGRAM FOR RECLAMATION
OF SURFACE AQUIFER
BEDROCK CONFIGURATION
JAN. 1961
18-04-01

PLATE 4

2

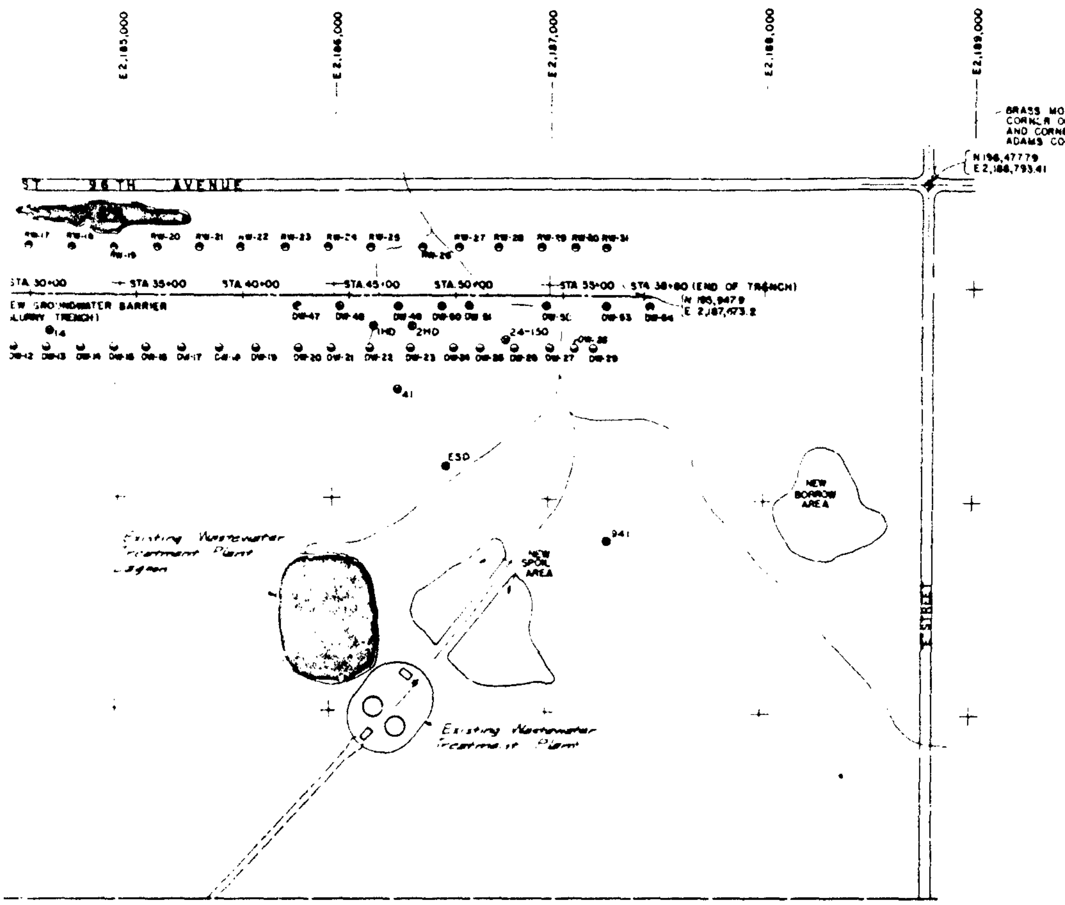


DEWATER WELLS		
WELL NO	STATION	OFFSET
DW-7	STA. 21 + 27	250' S
DW-8	STA. 22 + [illegible]	246' S
DW-9	STA. 24 + 42	246' S
DW-10	STA. 26 + 10	246' S
DW-11	STA. 27 + [illegible]	246' S
DW-12	STA. 28 + 72	246' S
DW-13	STA. 30 + [illegible]	246' S
DW-14	STA. 32 + 43	246' S
DW-15	STA. 33 + 97	246' S
DW-16	STA. 36 + 51	246' S
DW-17	STA. 37 + 16	246' S
DW-18	STA. 38 + [illegible]	246' S
DW-19	STA. 40 + [illegible]	246' S
DW-20	STA. 42 + 50	246' S
DW-21	STA. 44 + 30	246' S
DW-22	STA. 46 + [illegible]	246' S
DW-23	STA. 47 + 81	246' S
DW-24	STA. [illegible] + 91	246' S
DW-25	STA. 51 + 16	246' S
DW-26	STA. 52 + 76	246' S
DW-27	STA. 54 + [illegible]	246' S
DW-28	STA. 56 + 56	246' S
DW-29	STA. 58 + 41	246' S
DW-30	STA. -(6 + 42)	300' SE
DW-31	STA. -(3 + 42)	300' SE
DW-32	STA. -(1 + 17)	250' SE
DW-33	STA. 1 + 16	250' SE
DW-34	STA. 4 + 46	300' SE
DW-35	STA. 6 + 36	200' S

DENVER SANDS DEWATER WELLS		
WELL NO	STATION	OFFSET
DW-36	STA. 3 + 13	50' SE
DW-37	STA. 7 + 42	50' S
DW-38	STA. 9 + 42	50' S
DW-39	STA. 11 + 42	50' S
DW-40	STA. 13 + 52	50' S
DW-41	STA. 15 + 52	50' S
DW-42	STA. 17 + 42	50' S
DW-43	STA. 19 + 62	50' S
DW-44	STA. 21 + 52	50' S
DW-45	STA. 23 + 52	50' S
DW-46	STA. 25 + 52	50' S
DW-47	STA. 42 + 57	50' S
DW-48	STA. [illegible] + 57	50' S
DW-49	STA. 37 + 77	50' S
DW-50	STA. 40 + 37	50' S
DW-51	STA. 46 + 67	50' S
DW-52	STA. 49 + 37	50' S
DW-53	STA. 57 + 07	50' S
DW-54	STA. 58 + 07	50' S

RECHARGE WELLS		
WELL NO	STATION	OFFSET
RW-13	STA. 21 + 90	250' N
RW-14	STA. 23 + 90	250' N
RW-15	STA. 25 + 90	230' N
RW-16	STA. 27 + 90	230' N
RW-17	STA. 29 + 90	230' N
RW-18	STA. 31 + 90	230' N
RW-19	STA. 33 + 90	230' N
RW-20	STA. 35 + 90	230' [illegible]
RW-21	STA. 37 + 90	230' N
RW-22	STA. 39 + 90	230' N
RW-23	STA. 41 + 90	230' N
RW-24	STA. 43 + 90	230' N
RW-25	STA. 45 + 90	240' N
RW-26	STA. 48 + 40	230' N
RW-27	STA. 50 + 16	230' N
RW-28	STA. 51 + 90	230' N
RW-29	STA. 53 + 90	230' N
RW-30	STA. 55 + 50	230' N
RW-31	STA. 56 + 90	230' N
RW-32	STA. -(5 + 53)	250' NW
RW-33	STA. -(3 + 53)	250' NW
RW-34	STA. -(1 + 53)	250' NW
RW-35	STA. 0 + 47	250' NW
RW-36	STA. 3 + 47	250' NW
RW-37	STA. 6 + 47	250' NW
RW-38	STA. 5 + 56	250' N

WELL LOCATION TABLES



N

NOTES.

1. WELL STATIONS BASED ON SLURRY TRENCH ℄ STATIONS.
2. OFFSETS ARE FROM SLURRY TRENCH ℄
3. SEE SHEET C-7N FOR MONITORING WELLS LOCATION PLAN
4. APPROXIMATE LOCATIONS OF PIEZOMETERS READ IN TABLE "3. ●

RECHARGE WELLS

WELL NO	STATION	OFFSET
RW-13	STA. 21 + 00	250' N
RW-14	STA. 23 + 00	230' N
RW-15	STA. 25 + 00	230' N
RW-16	STA. 27 + 00	230' N
RW-17	STA. 29 + 00	230' N
RW-18	STA. 31 + [illegible]	230' N
RW-19	STA. 33 + 00	230' N
RW-20	STA. 35 + 00	2[illegible]' N
RW-21	STA. 37 + 00	230' N
RW-22	STA. 39 + 00	230' N
RW-23	STA. 41 + 00	230' N
RW-24	STA. 43 + 00	230' N
RW-25	STA. 45 + 00	230' N
RW-26	STA. 48 + 00	230' N
RW-27	STA. 50 + 50	230' N
RW-28	STA. 51 + [illegible]	230' N
RW-29	STA. 53 + 00	230' N
RW-30	STA. 56 + 50	230' N
RW-31	STA. 58 + 03	230' N
RW-3[illegible]	STA. -(5 + 53)	250' [illegible]
[illegible]	STA. -(3 + 53)	250' [illegible]
RW-34	STA. -(1 + 53)	250' [illegible]
RW-35	STA. 0 + 47	250' [illegible]
RW-36	STA. 2 + 47	250' [illegible]
RW-37	STA. 4 + 47	250' [illegible]
RW-38	STA. 6 + 55	250' N

REWORKED DEWATER WELLS

WELL NO.	OFFSET
DW-1R	245'S
DW-2R	245'S
DW-3R	245'S
DW-4R	245'S
DW-5R	245'S
DW-6R	245'S

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	BY OR	APPR'D

REVISIONS

PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

DRAWN BY WPS / VPD
CHECKED BY JER

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
RECHARGE AND DEWATER WELLS LOCATION PLAN

DATE JUNE 1980

SCALE AS SHOWN

DACA45 80 R 0161

71-07-16

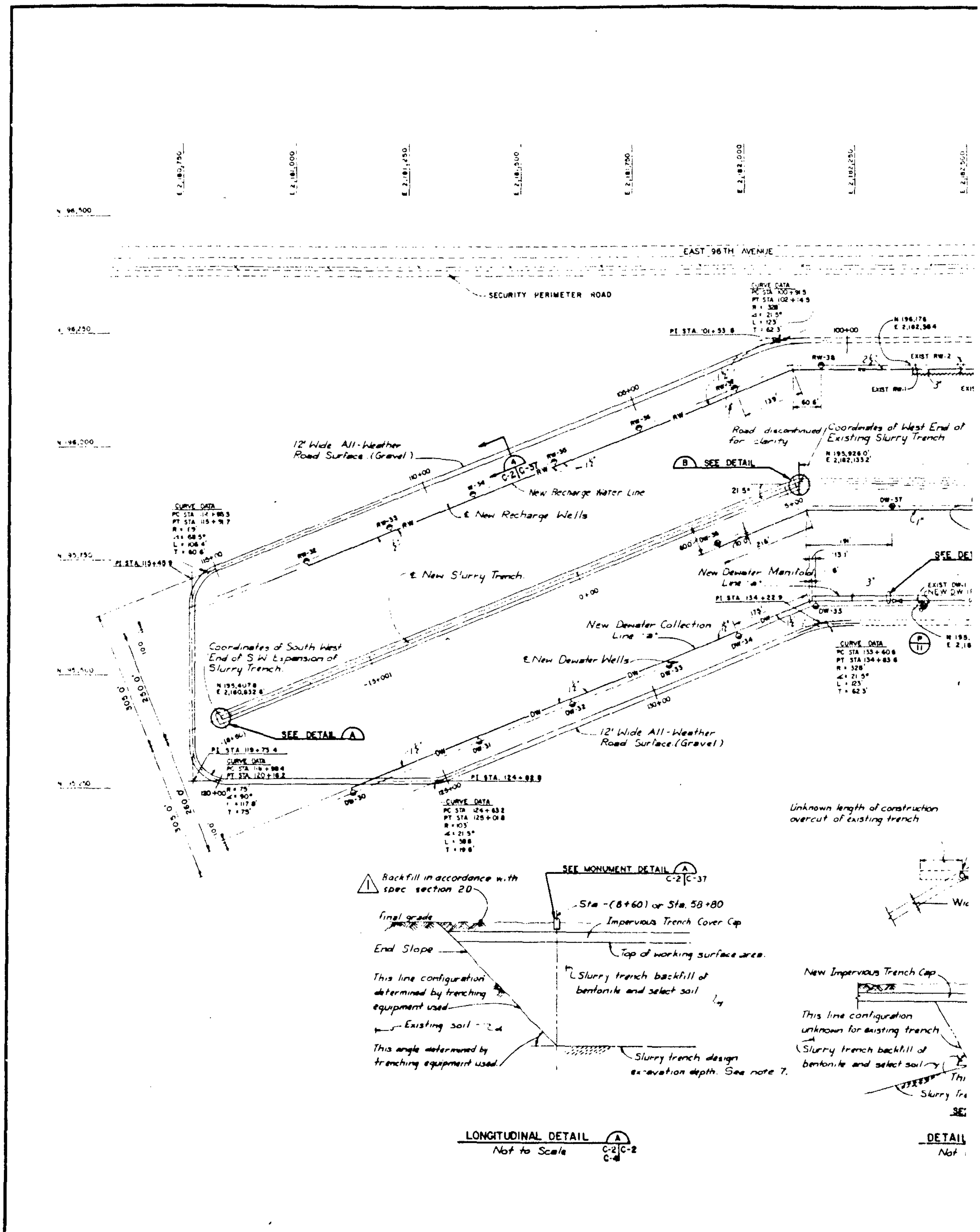
SAFETY PAYS

1" = 500'

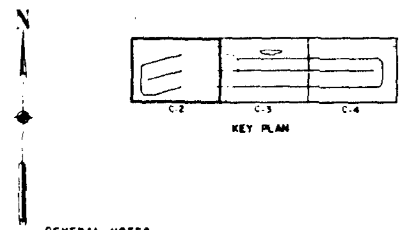
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICATION NO.

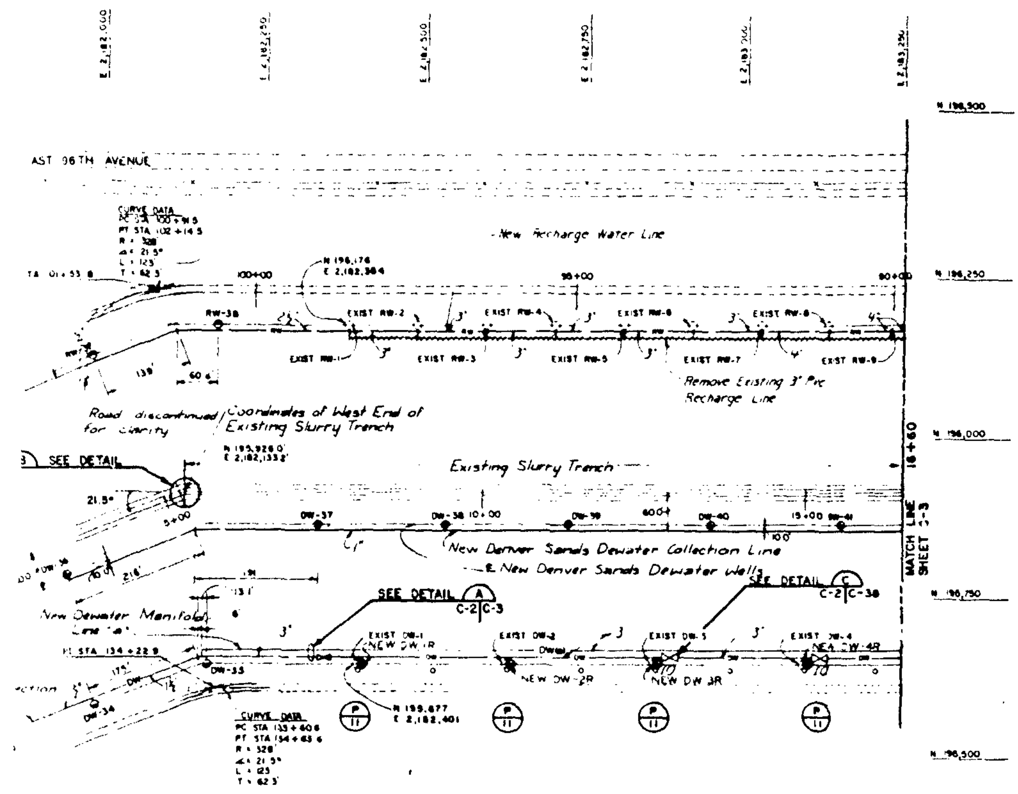
$$ – THINK VALUE ENGINEERING – $$

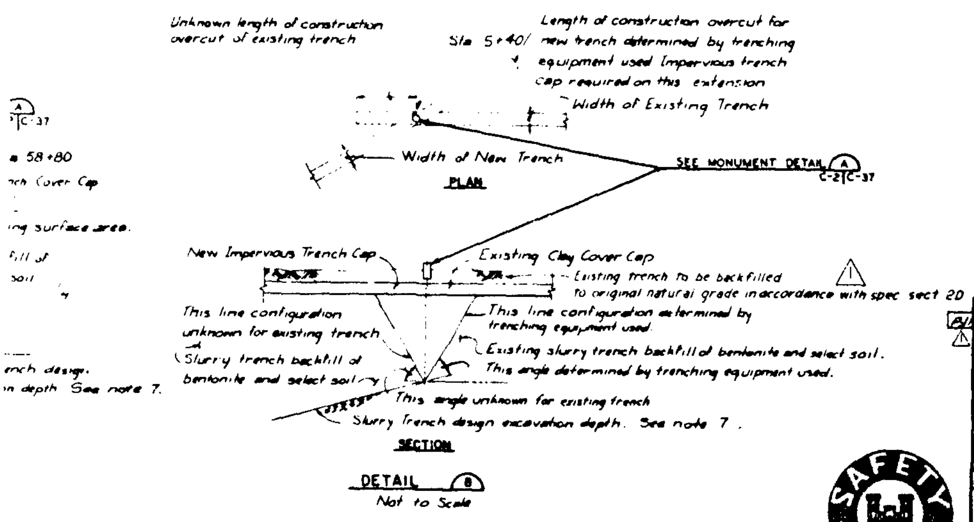
PLATE 6



EAST 96TH AVENUE
SECURITY PERIMETER ROAD
12' Wide All-Weather Road Surface (Gravel)
New Recharge Water Line
℄ New Recharge Wells
℄ New Slurry Trench
Road discontinued for clarity
Coordinates of West End of Existing Slurry Trench
SEE DETAIL B
New Dewater Manifold Line "a"
SEE DETAIL
New Dewater Collection Line "a"
℄ New Dewater Wells
Coordinates of South West End of S.W. Expansion of Slurry Trench
SEE DETAIL A
12' Wide All-Weather Road Surface (Gravel)
CURVE DATA
Unknown length of construction overcut of existing trench
Backfill in accordance with spec section 20
SEE MONUMENT DETAIL A C-2 C-37
Sta -(8+60) or Sta. 58+80
Final grade
Impervious Trench Cover Cap
End Slope
Top of working surface area
This line configuration determined by trenching equipment used
Slurry trench backfill of bentonite and select soil
Existing soil
This angle determined by trenching equipment used
Slurry trench design excavation depth. See note 7.
New Impervious Trench Cap
This line configuration unknown for existing trench
Slurry trench backfill of bentonite and select soil
LONGITUDINAL DETAIL A
Not to Scale
DETAIL







GENERAL NOTES:

1. WATER REQUIRED BY THE CONTRACTOR FOR GENERAL CONSTRUCTION CAN BE OBTAINED FROM GROUNDWATER DEWATERING WELLS AND/OR THE TREATED WATER EFFLUENT SUMP LOCATED AT BUILDING 808. WATER FOR THE SLURRY TRENCH SHALL BE OBTAINED FROM THE TREATED WATER EFFLUENT SUMP. ADDITIONAL WATER FOR USE IN SLURRY TRENCH CONSTRUCTION SHALL BE THE CONTRACTOR'S RESPONSIBILITY
2. DEWATER AND RECHARGE WELLS, NUMBER DW 7 THROUGH DW 35, AND RW 13 THROUGH RW 38 MUST BE INSTALLED AND ALL THESE WELLS AND ALL EXISTING WELLS MUST BE OPERATIONAL PRIOR TO CONSTRUCTION OF THE BENTONITE SLURRY TRENCH
3. DEWATER WELLS NUMBER DW 36 THROUGH DW 54 LOCATED IN THE DENVER SANDS FORMATION CAN BE INSTALLED FOLLOWING CONSTRUCTION OF THE GROUNDWATER BARRIER AND BACKFILLING OF THE BARRIER TRENCH WORKING SURFACE.
4. CONTRACTOR SHALL VERIFY THE LOCATION OF THE EAST AND WEST LIMITS OF THE EXISTING SLURRY TRENCH TO ITS DESIGN DEPTH BY AUGER BORING. APPROVAL BY THE CONTRACTING OFFICER OF THIS VERIFICATION SHALL BE OBTAINED BEFORE PROCEEDING WITH EXPANSION OF THE SLURRY TRENCH.
5. COORDINATES FOR EXISTING DEWATER AND RECHARGE WELLS DW 1, DW 6, RW 1, AND RW 12 SHALL BE FIELD VERIFIED.
6. LIMITS OF DEWATER MANIFOLD LINES "A", "B" AND "C" DETERMINED BY VALVE CONFIGURATIONS AS SHOWN ON SHEETS C-2, C-3, AND C-4.
7. REFER TO SHEETS C-13 THROUGH C-16 FOR SLURRY TRENCH MINIMUM EXCAVATION DEPTHS
8. EXISTING DEWATER AND RECHARGE WELLS ARE TO BE MODIFIED TO CONFORM TO THESE PLANS AND SPECIFICATIONS
9. EXISTING RECHARGE LINE AND ALL CONTROLS ARE TO BE REMOVED.
10. EXISTING DEWATER PUMPS, CONTROLS, PIPING AND VALVES CONNECTED TO THE EXISTING COLLECTION LINE ARE TO BE REMOVED.
11. PIEZOMETERS TO BE SAVED WILL BE IDENTIFIED BY RMA AND SHALL BE FIELD VERIFIED BY THE CONTRACTOR. CONTRACTOR SHALL REPLACE, AT HIS EXPENSE, ANY OF THOSE DESTROYED OR DAMAGED DURING CONSTRUCTION WITH 4 INCH PIEZOMETERS, IN ACCORDANCE WITH SPECIFICATION SECTIONS 13B AND 13C.
12. CLEARING AND GRUBBING SHALL BE PERFORMED ON AREAS WITHIN LINES 10 FEET OUTSIDE EACH BUILDING OR STRUCTURE LINE, WITHIN THE LIMITS OF NEW ROADWAY CONSTRUCTION, WITHIN THE LIMITS OF THE RECOMMENDED SLURRY TRENCH WORKING SURFACE, AND ELSEWHERE IN ACCORDANCE WITH THE SPECIFICATIONS
13. THRUST BLOCKING TO BE PROVIDED ON 6 INCH LINES AS INDICATED ON DETAIL D C-2|C-38
14. REFER TO SHEETS C-26 & C-27 FOR WORKING SURFACE CONTOURS & TO SHEETS C-28 THRU C-36 FOR WORKING SURFACE ELEVATIONS
15. THE CONTRACTOR SHALL PLACE A VALVE IN THE DEWATER WELL COLLECTION LINE AS INDICATED, ACCORDING TO THESE PLANS AND SPECIFICATIONS
16. DW-1, DW-2, DW-3, DW-4, DW-5 AND DW-6 SHALL BE REPLACED BY THE CONTRACTOR WITH DW-1R, DW-2R, DW-3R, DW-4R, DW-5R AND DW-6R AS INDICATED. LOCATION OF EACH REPLACMENT WELL IS 7' EAST OF THE ORIGINAL WELL

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

	DATE	DESCRIPTION	MADE	APPR'D
B	8-5-81	Added Note #15 & 16 Added valve & IR to 6R		
1	8-13-80	AM #0001 GENERAL REVISIONS		DHA

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

DESIGNED BY: DAD/VMR
DRAWN BY: V.P.G/MNM
CHECKED BY: JER

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
SITE PLAN
SHEET 1 OF 3
34

DATE: JUNE 1980
SCALE AS SHOWN
SPEC. NO. DACA45 80 R 0161
71-07-16

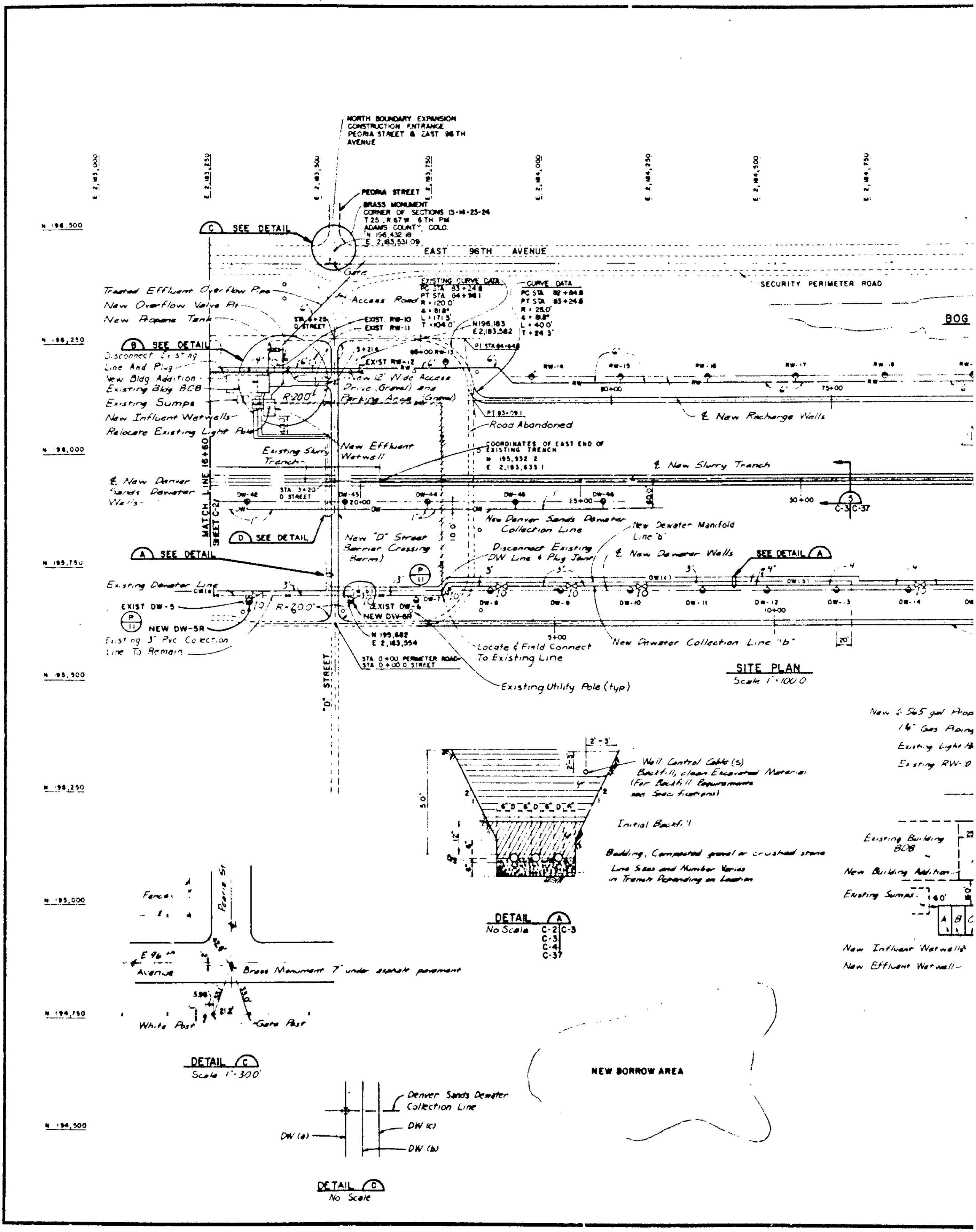
SAFETY PAYS

100' 50' 0 100' 200'
1" = 100'

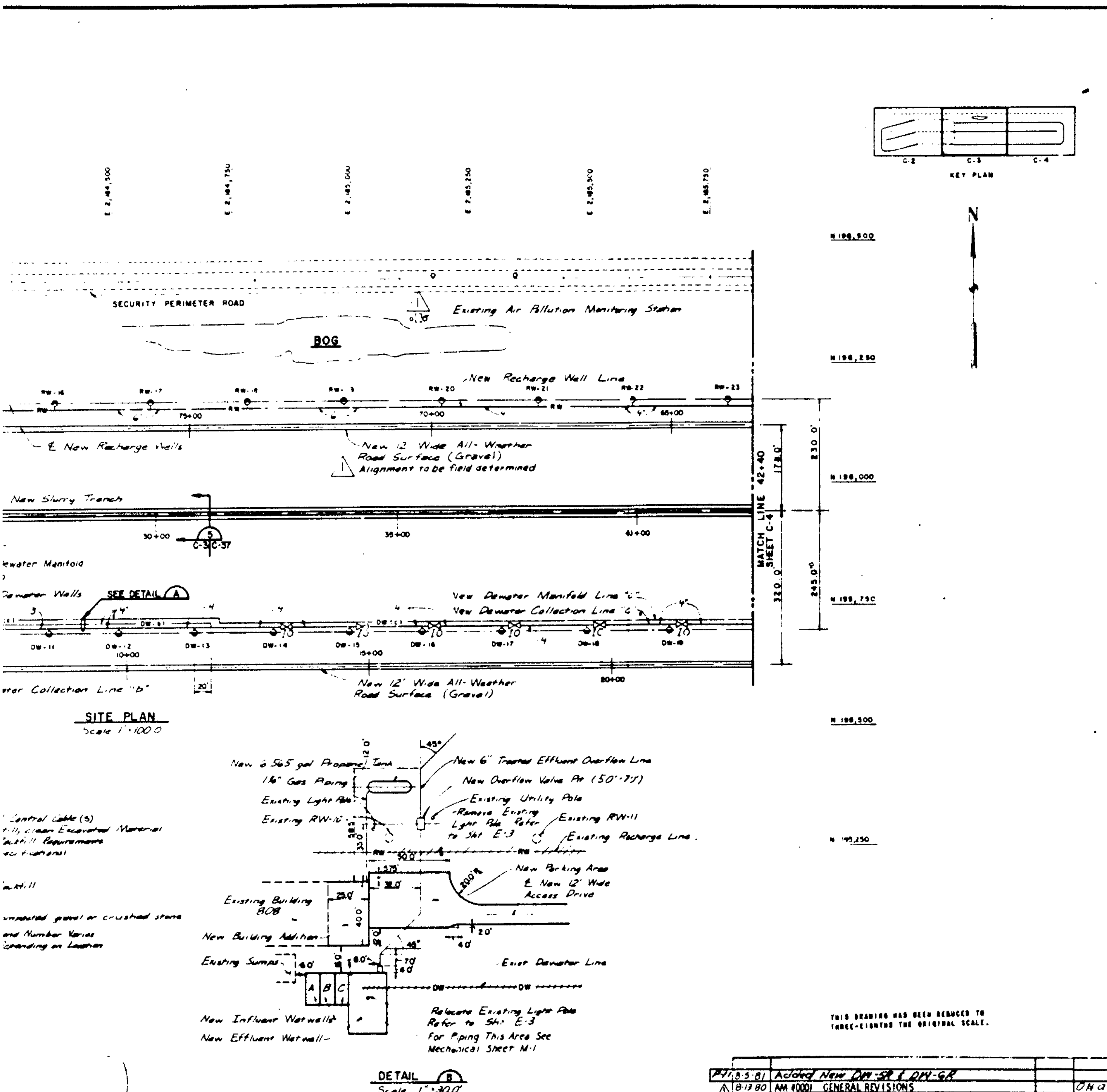
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 81 C054 MODIFICATION NO. P00011

$$ – THINK VALUE ENGINEERING – $$

PLATE 7



NORTH BOUNDARY EXPANSION CONSTRUCTION ENTRANCE PEORIA STREET & EAST 96TH AVENUE
PEORIA STREET
BRASS MONUMENT
SEE DETAIL C
EAST 96TH AVENUE
SECURITY PERIMETER ROAD
Access Road
Treated Effluent Overflow Pipe
New Overflow Valve Pit
New Propane Tank
SEE DETAIL B
Disconnect Existing Line And Plug
New Bldg Addition
Existing Bldg 808
Existing Sumps
New Influent Wetwells
Relocate Existing Light Pole
New 12' Wide Access Drive (Gravel) and Parking Area (Gravel)
Road Abandoned
BOG
New Recharge Wells
Existing Slurry Trench
New Effluent Wetwell
New Slurry Trench
New Denver Sands Dewater Wells
MATCH LINE 16+60 SHEET C-21
SEE DETAIL D
New Denver Sands Dewater Collection Line
New Dewater Manifold Line "b"
New "D" Street Barrier Crossing (Berm)
Disconnect Existing DW Line & Plug Tee
New Dewater Wells
SEE DETAIL A
Existing Dewater Line
EXIST DW-5
NEW DW-5R
Existing 3" Pvc Collection Line To Remain
EXIST DW-6
NEW DW-6R
Locate & Field Connect To Existing Line
New Dewater Collection Line "b"
Existing Utility Pole (typ)
"D" STREET
SITE PLAN
Scale 1" = 100'
Wall Control Cable (s)
Backfill, clean Excavated Material (For Backfill Requirements see Specifications)
Initial Backfill
Bedding, Compacted gravel or crushed stone
Line Sizes and Number Varies in Trench Depending on Location
DETAIL A
No Scale
Fence
Peoria St
E 96th Avenue
Brass Monument 7" under asphalt pavement
White Post
Gate Post
DETAIL C
Scale 1" = 300'
NEW BORROW AREA
Denver Sands Dewater Collection Line
DW (a)
DW (b)
DW (c)
DETAIL D
No Scale
Existing Building 808
New Building Addition
Existing Sumps
New Influent Wetwells
New Effluent Wetwell



THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

P	8-5-81	Added New DW-5R & DW-6R	
1	8-13-80	AM #0001 GENERAL REVISIONS	OHA
DATE		DESCRIPTION	MADE / APPR

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

Designed by VMR/DAD
Drawn by VPG/MWH
Checked by JER

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

SITE PLAN SHEET 2 OF 3

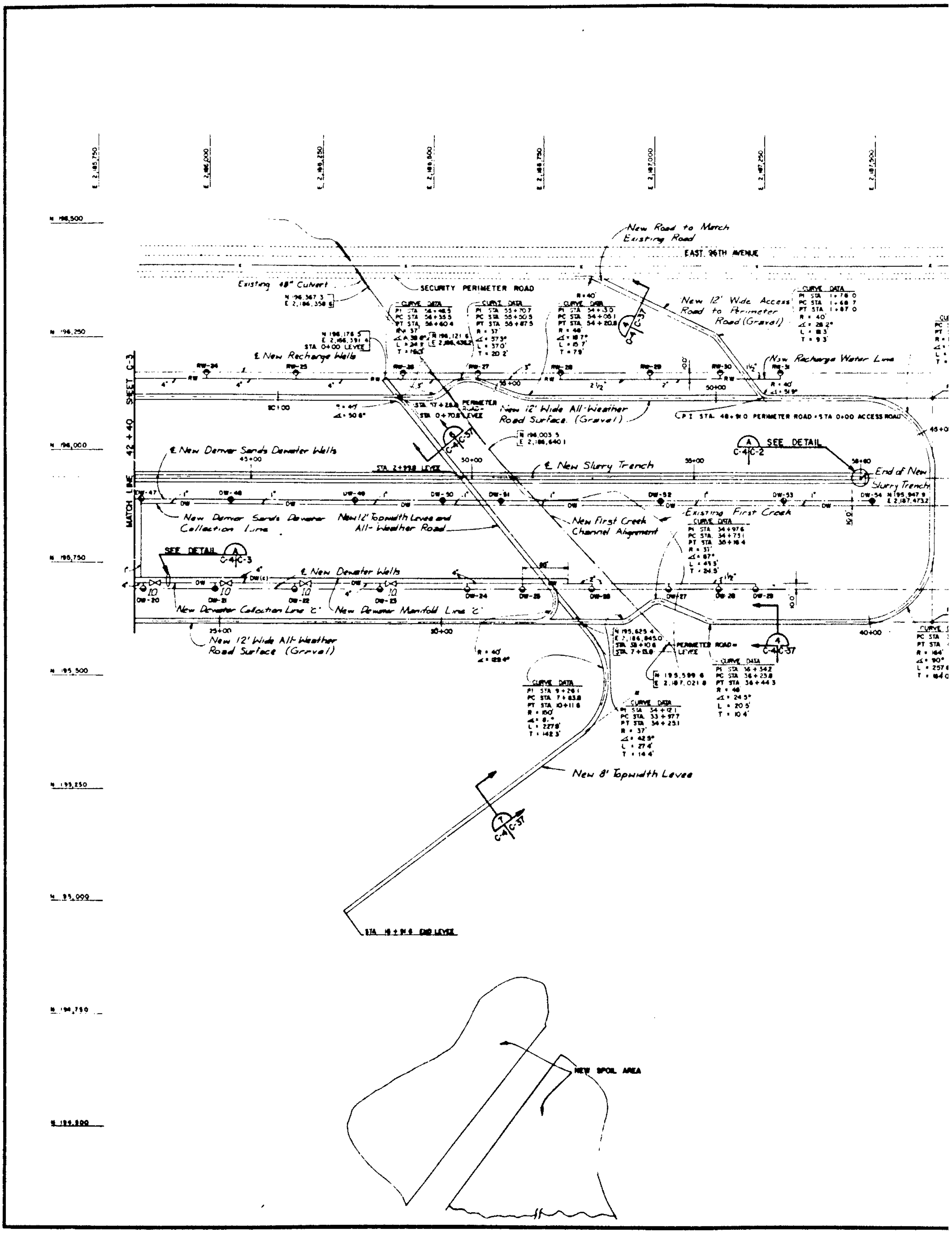
Date JUNE 1980

Scale AS SHOWN

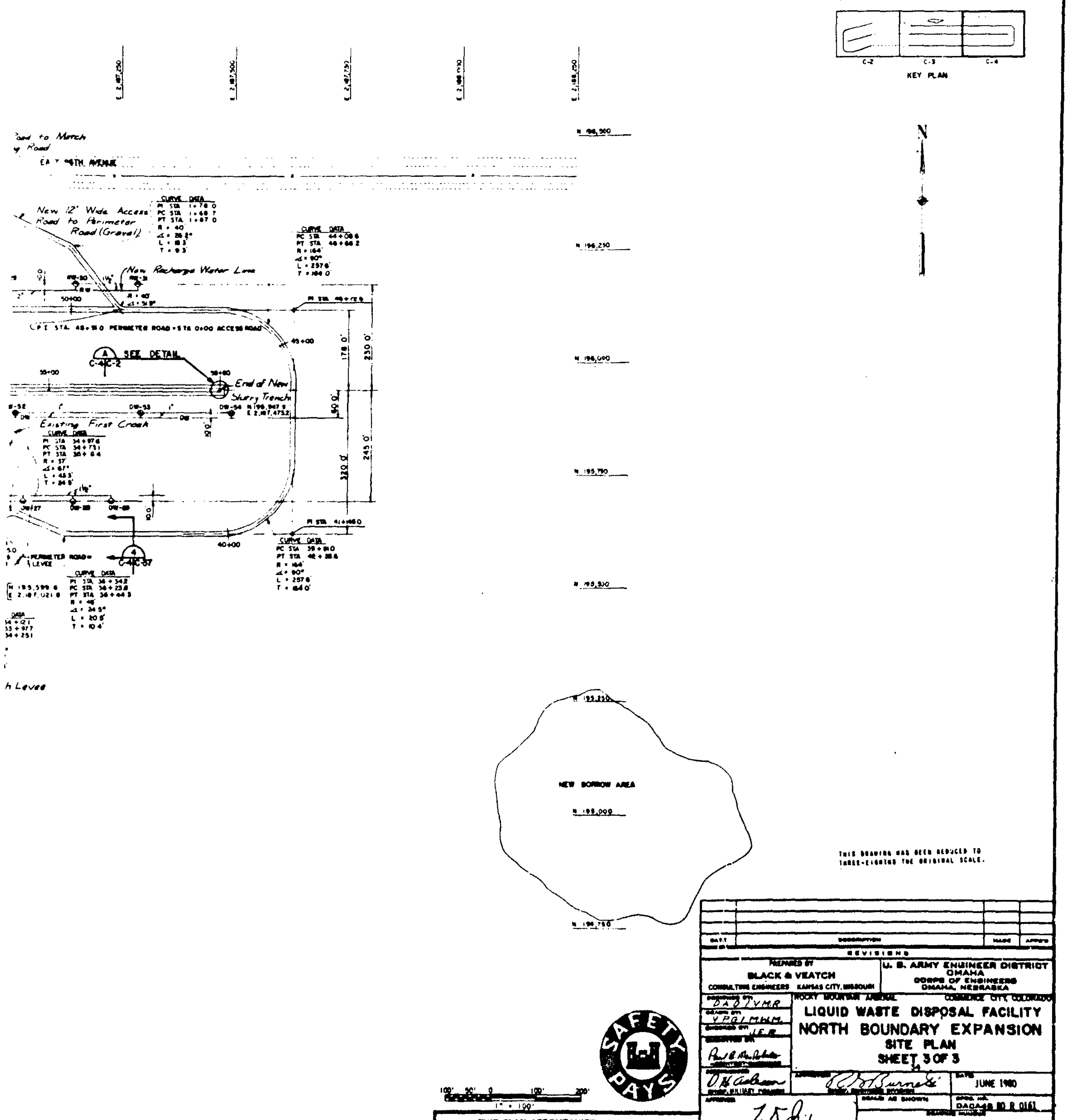
71-07-16

Sheet C-3

THIS PLAN ACCOMPANIES CONTRACT No. DACA 45-81-C054 MODIFICATION No. P00011



New Road to Match Existing Road
EAST 96TH AVENUE
Existing 48" Culvert
SECURITY PERIMETER ROAD
New 12' Wide Access Road to Perimeter Road (Gravel)
℄ New Recharge Wells
New Recharge Water Line
New 12' Wide All-Weather Road Surface. (Gravel)
℄ New Denver Sands Dewater Wells
SEE DETAIL
℄ New Slurry Trench
End of New Slurry Trench
New Denver Sands Dewater Collection Line
New 12' Topwidth Levee and All-Weather Road
New First Creek Channel Alignment
Existing First Creek
CURVE DATA
℄ New Dewater Wells
New Dewater Collection Line 'C'
New Dewater Manifold Line 'C'
New 12' Wide All-Weather Road Surface (Gravel)
PERIMETER ROAD = LEVEE
New 8' Topwidth Levee
NEW SPOIL AREA
MATCH LINE 42+40 SHEET C-3



PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
SITE PLAN
SHEET 3 OF 3

JUNE 1980

SCALE AS SHOWN

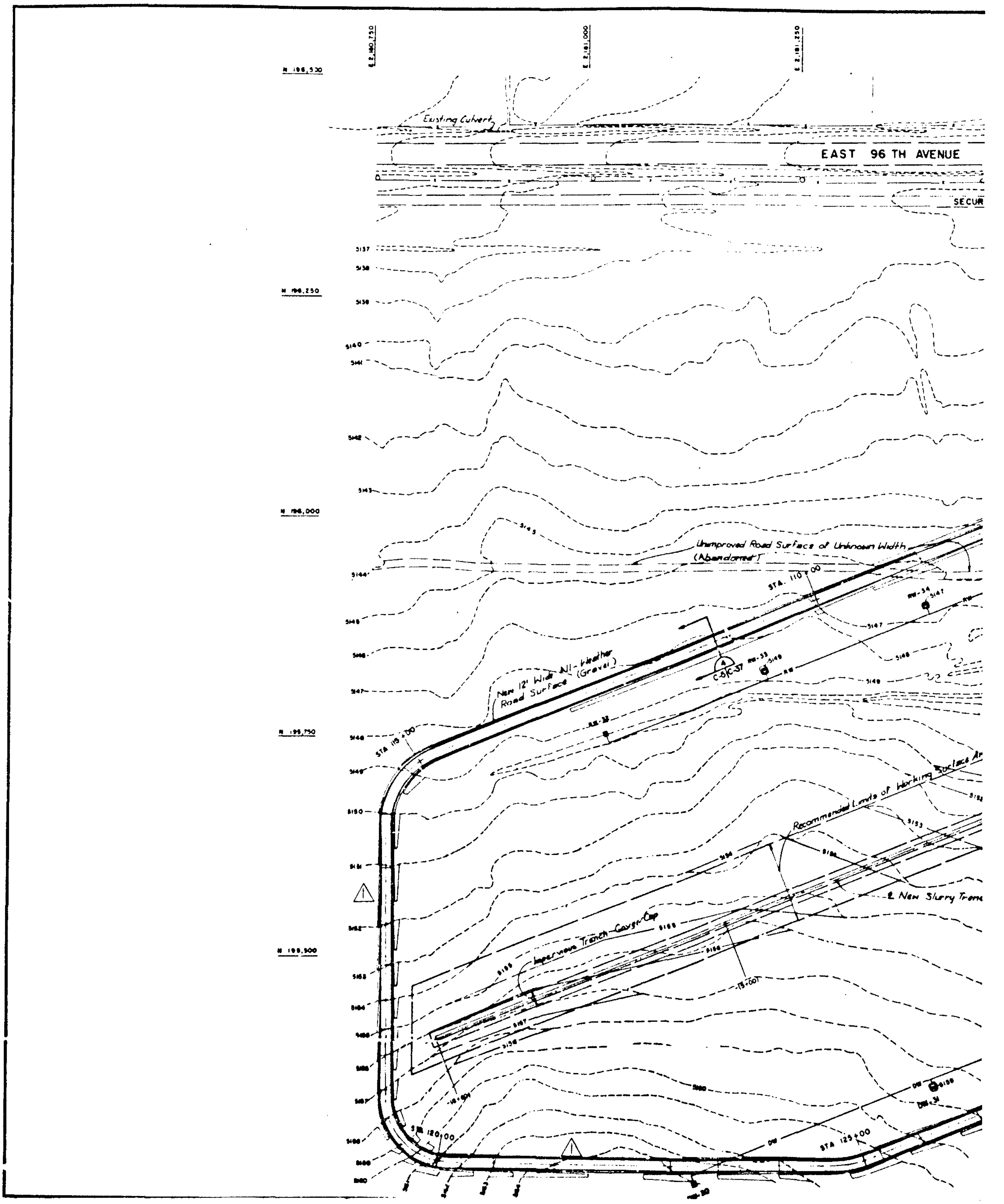
DACA45-80-R-0161

71-07-16

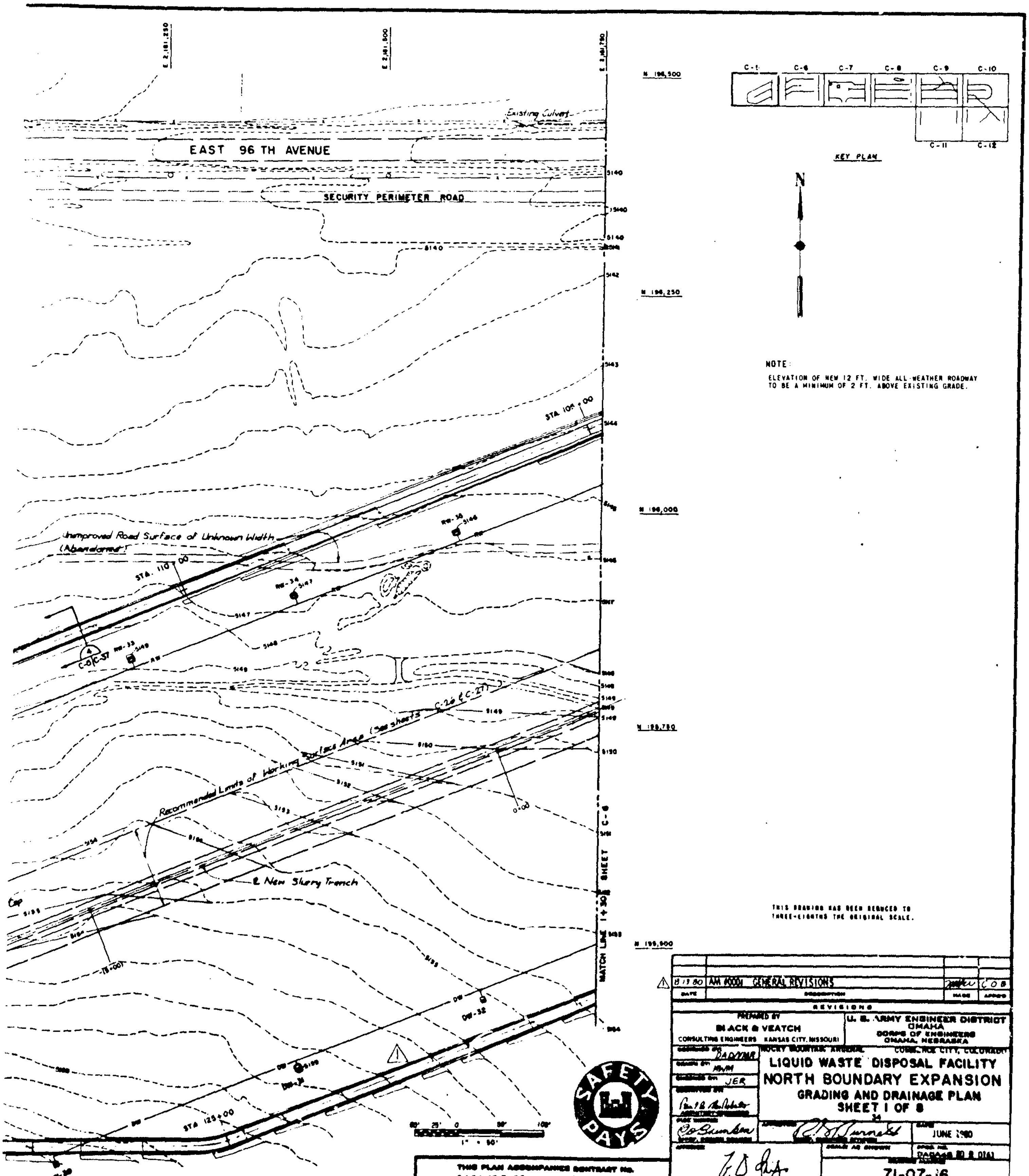
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 C0 MODIFICATION NO.

$$ – THINK VALUE ENGINEERING – $$

PLATE 9

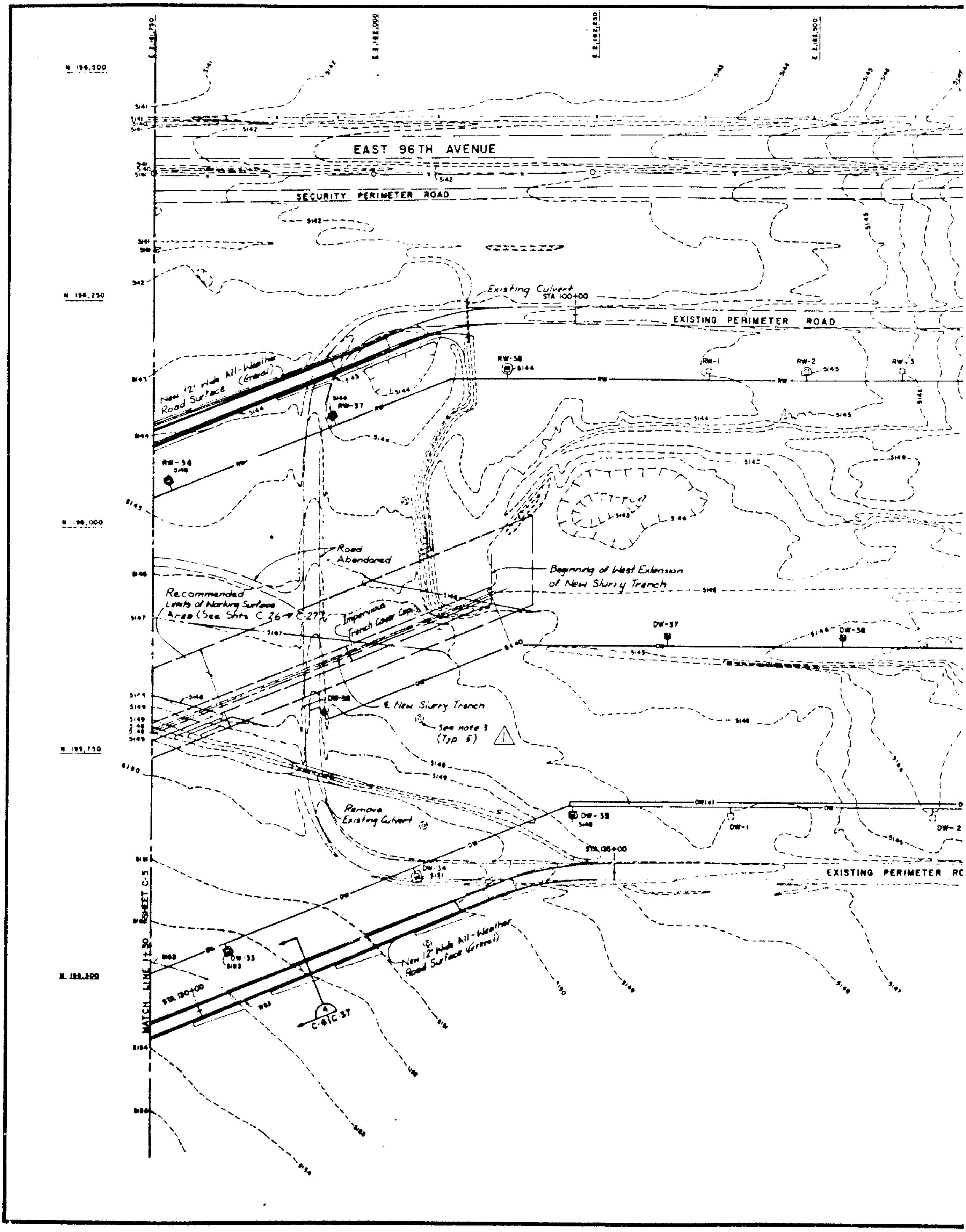


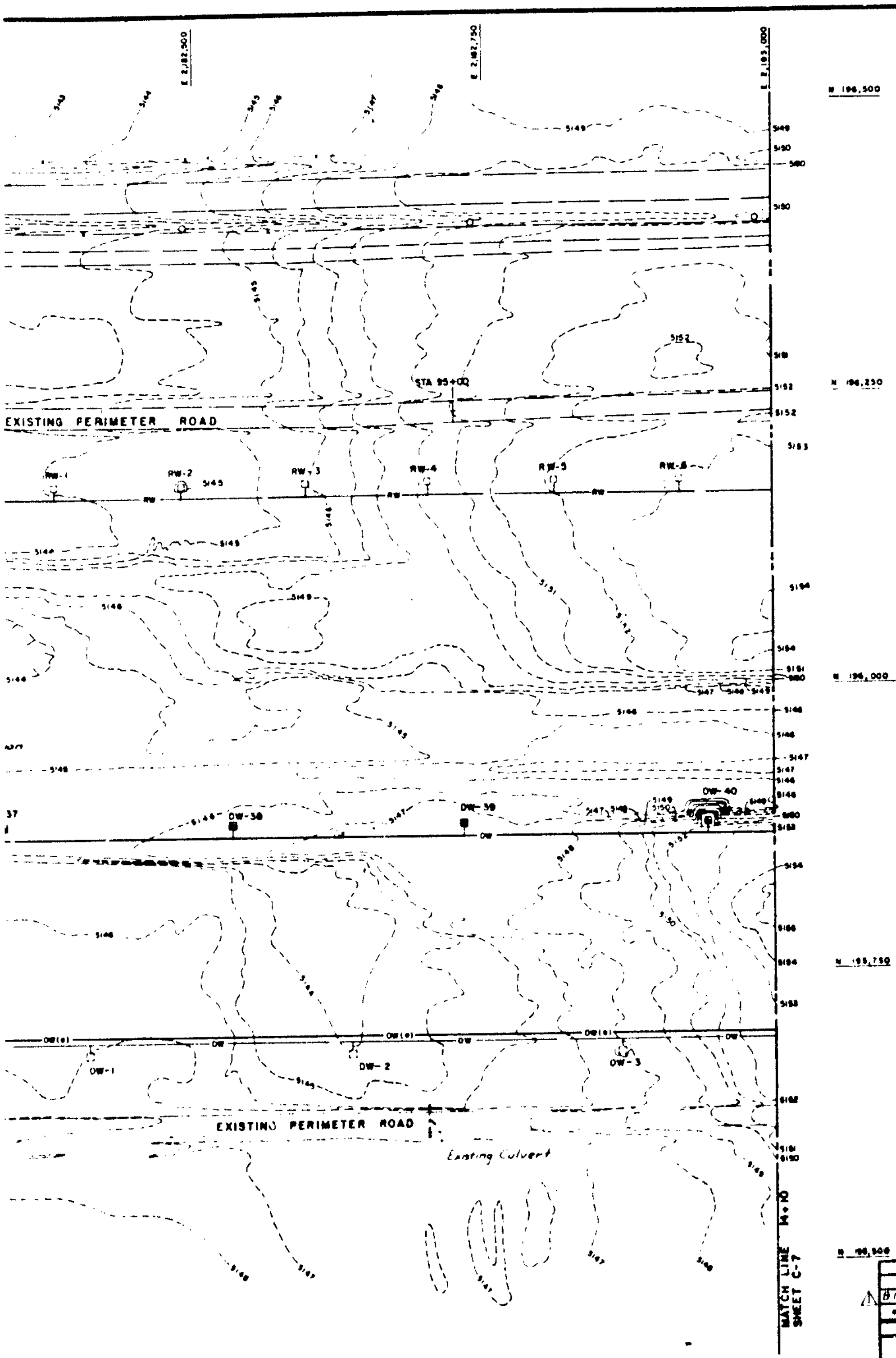
E 2,180,750
E 2,181,000
E 2,181,250
N 196,250
N 196,000
N 195,750
N 195,500
Existing Culvert
EAST 96 TH AVENUE
Unimproved Road Surface of Unknown Width
(Abandoned)
STA. 110+00
New 12' Wide All-Weather
Road Surface (Gravel)
STA 115+00
Recommended Limits of Working Surface
New Slurry Trench
Impervious Trench Cover Cap
STA 120+00
STA 125+00

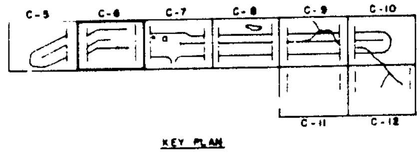


$$ – THINK VALUE ENGINEERING – $$

PLATE 10


EAST 96TH AVENUE
SECURITY PERIMETER ROAD
EXISTING PERIMETER ROAD
Existing Culvert
STA 100+00
New 12' Wide All-Weather Road Surface (Gravel)
Road Abandoned
Recommended Limits of Working Surface Area (See Shts C 26 & C 27)
Impervious Trench Cover Cap
Beginning of West Extension of New Slurry Trench
℄ New Slurry Trench
See note 3 (Typ 6)
Remove Existing Culvert
STA 135+00
EXISTING PERIMETER RC
New 12' Wide All-Weather Road Surface (Gravel)
STA 130+00
MATCH LINE 130+30 SHEET C-5
RW-1
RW-2
RW-3
RW-36
RW-37
RW-38
DW-1
DW-2
DW-33
DW-34
DW-35
DW-36
DW-37
DW-38
N 196,500
N 196,250
N 196,000
N 195,750
N 195,500
E 2,181,750
E 2,182,000
E 2,182,250
E 2,182,500





NOTES

1. ELEVATION OF NEW 12 FT WIDE ALL WEATHER ROADWAY TO BE A MINIMUM OF 2 FT ABOVE EXISTING GRADE
2. EXISTING TRENCH WORKING SURFACE AREA TO BE BACKFILLED TO ORIGINAL EXIST NATURAL GRADE
3. APPROXIMATE LOCATIONS OF EXIST 6" DIAMETER STEEL WELL HEADS LOCATE & REMOVE CONNECTING PIPE THROUGH WORKING AREA & PLUG

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPR'D
8 19 80	AM P003 GENERAL REVISIONS		C O B

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GRADING AND DRAINAGE PLAN
SHEET 2 OF 8

JAD / VMH
MWM
LER

DATE: JUNE 1980

SCALE AS SHOWN

71-07-16

C-6

1" = 60'

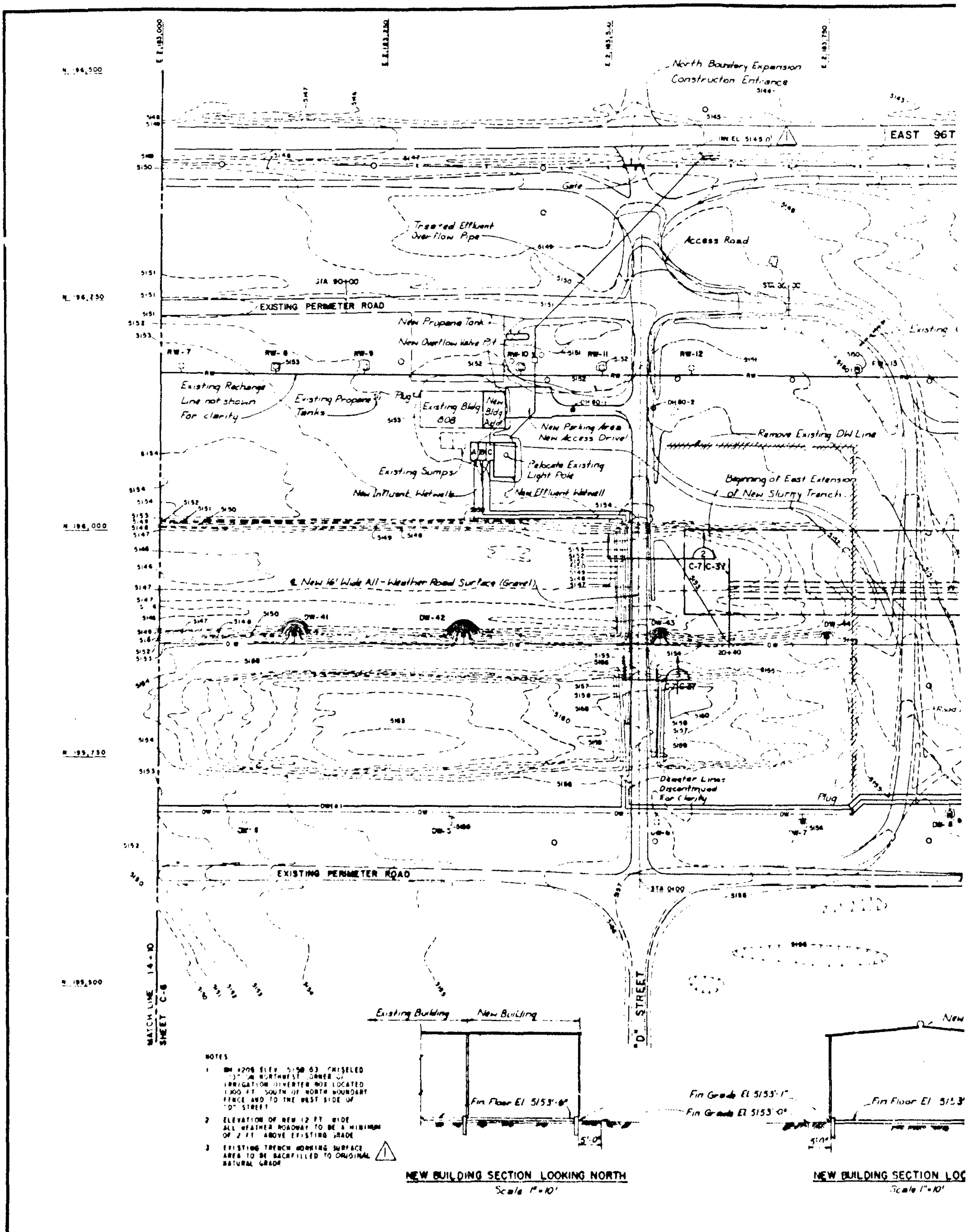
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 ? CO MODIFICATION NO.

SAFETY PAYS

PLATE 11

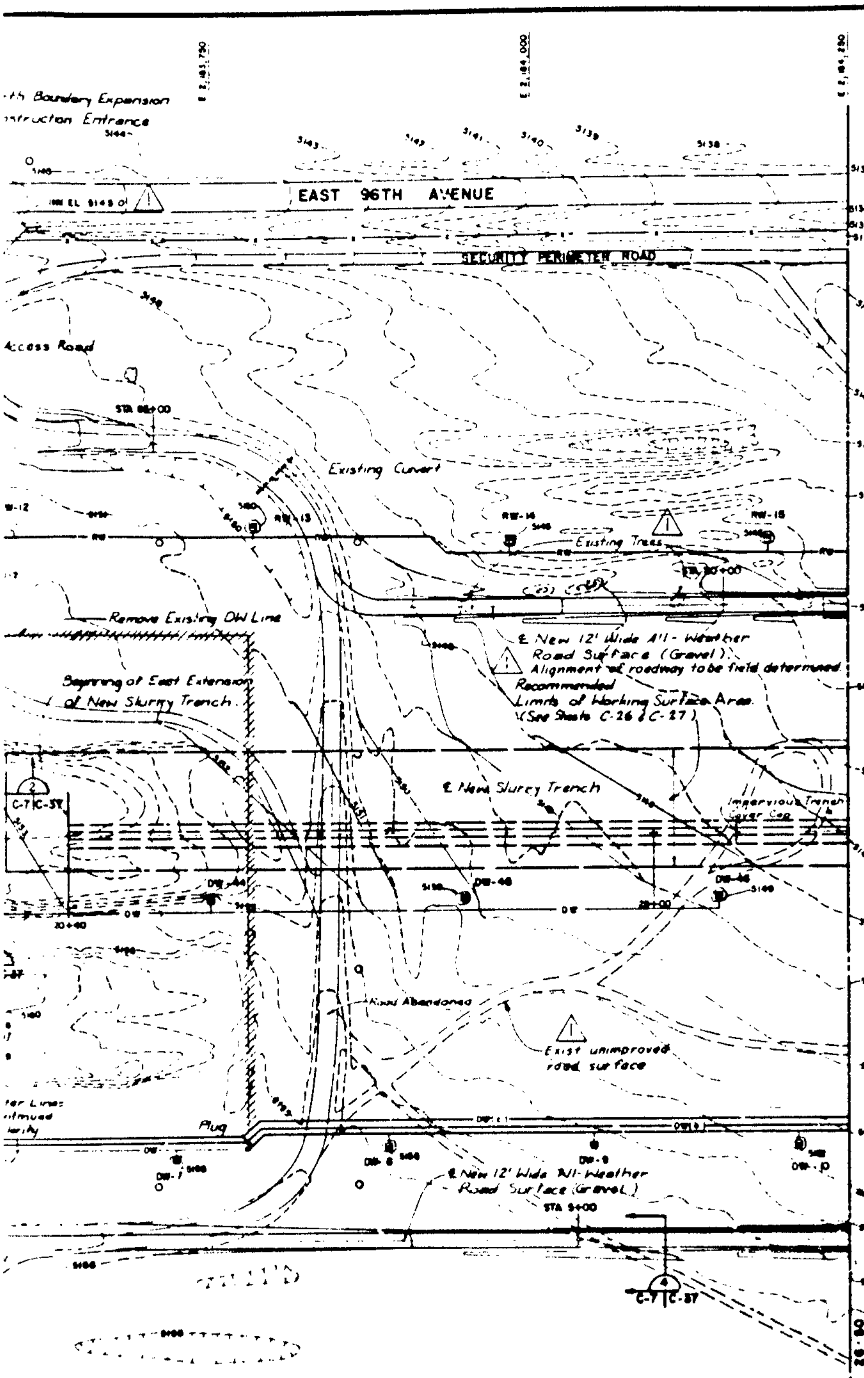
$$ – THINK VALUE ENGINEERING – $$

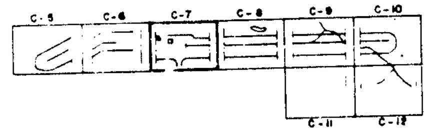
7



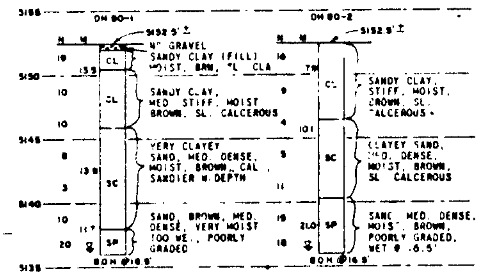
NOTES

1. BM #208 ELEV. 5150.63 CHISELED "O" ON NORTHWEST CORNER OF IRRIGATION DIVERTER BOX LOCATED 1300 FT. SOUTH OF NORTH BOUNDARY FENCE AND TO THE WEST SIDE OF "D" STREET
2. ELEVATION OF NEW 12 FT. WIDE ALL WEATHER ROADWAY TO BE A MINIMUM OF 2 FT. ABOVE EXISTING GRADE
3. EXISTING TRENCH WORKING SURFACE AREA TO BE BACKFILLED TO ORIGINAL NATURAL GRADE





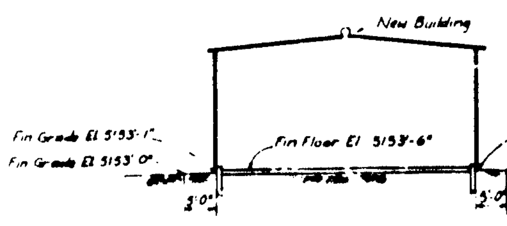
KEY PLAN



NOTES.
1. BOTH BORINGS DRILLED 15 JAN. 1980.
2. ELEVATIONS TAKEN FROM TOPO INTERPRETATION.
3. N = STANDARD PENETRATION NUMBER, BLOWS / FT.
4. W = NATURAL MOISTURE CONTENT IN PERCENT.
5. BORINGS SHOWN IN PLAN VIEW ON THIS SHEET.
6. BORING DH80-1 STAYED OPEN TO 16.0 FEET.
7. THESE BORINGS TAKEN FROM OMAHA DISTRICT, COE F AND M REPORT DATE 26 FEB. 1980.

SUBSURFACE DATA

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.



NEW BUILDING SECTION LOOKING WEST
Scale 1"=10'

1" = 10'

1" = 50'

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICATION NO.

8/19/80	AM #0001 GENERAL REVISIONS		COB
DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

DESIGNED BY: BLACK & VEATCH, CONSULTING ENGINEERS, KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

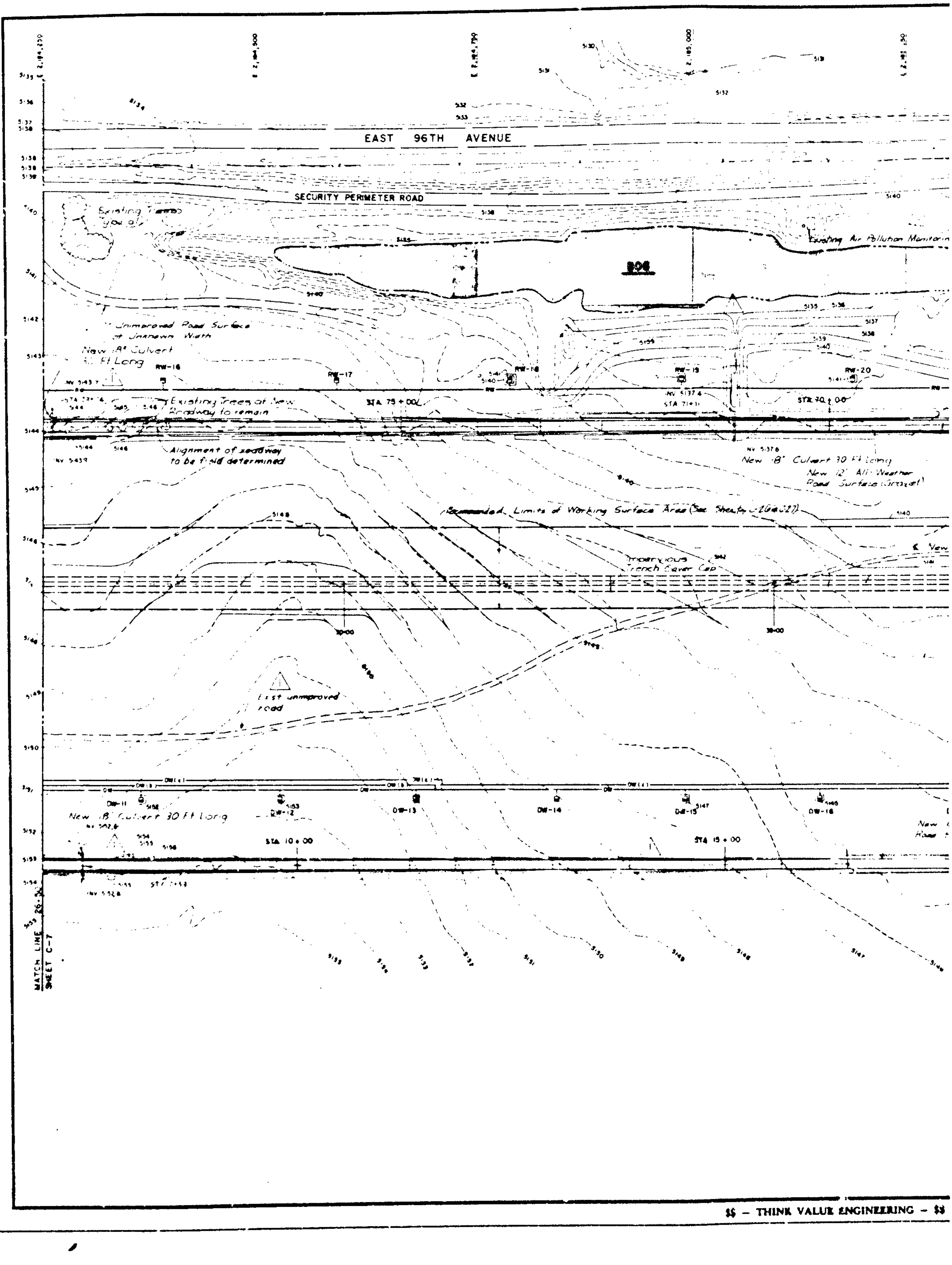
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GRADING AND DRAINAGE PLAN
SHEET 3 OF 6

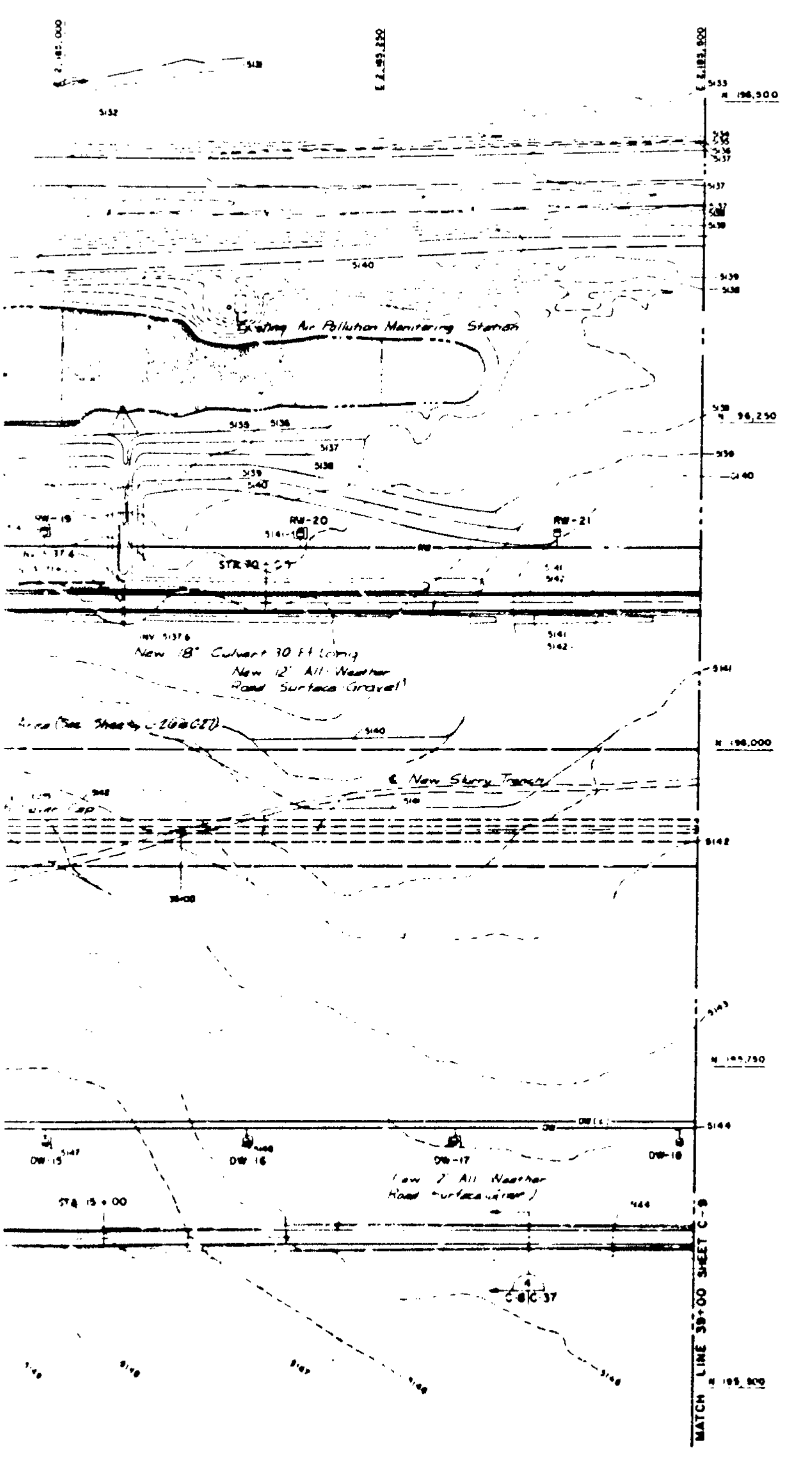
DESIGNED BY: DAD/KMR
DRAWN BY: MWM
CHECKED BY: JAB

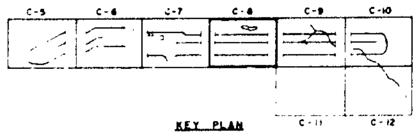
DATE: JUNE 1980
SCALE: AS SHOWN
DACA45 80 R 0161
71-07-16
SHEET C-7

PLATE 12

$$ — THINK VALUE ENGINEERING — $$


EAST 96TH AVENUE
SECURITY PERIMETER ROAD
Existing Trees
Existing Air Pollution Monitoring
Unimproved Road Surface of Unknown Width
New 18" Culvert
RW-16
RW-17
RW-18
RW-19
RW-20
STA 75+00
STA 70+00
Existing Trees at New Roadway to remain
Alignment of roadway to be field determined
New 18" Culvert 30 Ft Long
New 12' All-Weather Road Surface (Gravel)
Limits of Working Surface Area
Impervious Trench Cover Cap
Exist unimproved road
DW-11
DW-12
DW-13
DW-14
DW-15
DW-16
STA 10+00
STA 15+00
MATCH LINE
SHEET C-7





KEY PLAN

NOTE

ELEVATION OF NEW 12 FT WIDE ALL WEATHER ROADWAY TO BE A MINIMUM OF 2 FT ABOVE EXISTING GRADE

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45-7 CO

DATE	DESCRIPTION	MADE	APPR'D
8-7-80	AM #001 GENERAL REVISIONS		COB

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

DESIGNED BY: UR/DAD

DRAWN BY: MWM

CHECKED BY:

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

GRADING AND DRAINAGE PLAN

SHEET 4 OF 8

DATE: JUNE 1980

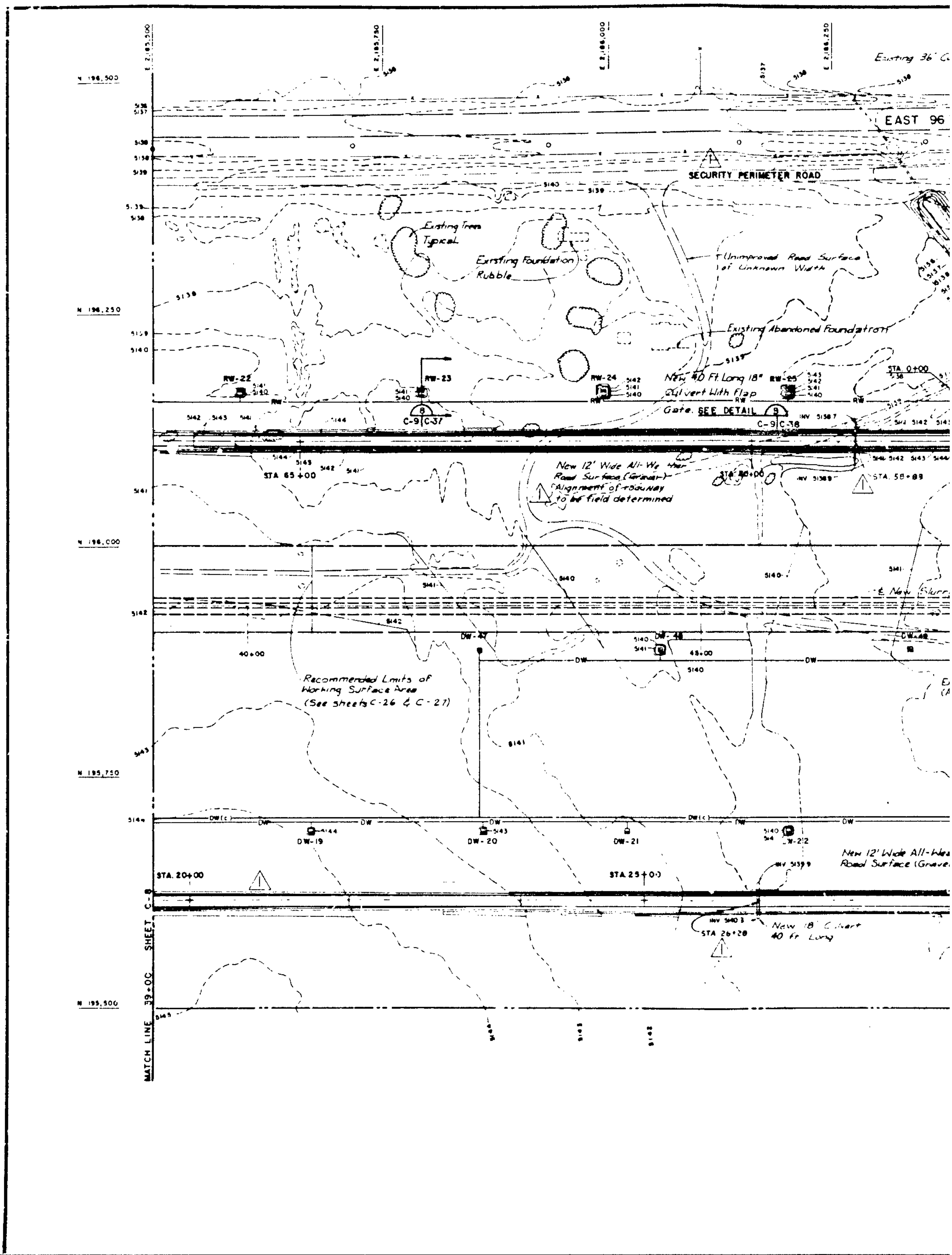
SCALE AS SHOWN

SPEC. NO. DACA45-80-B-0141

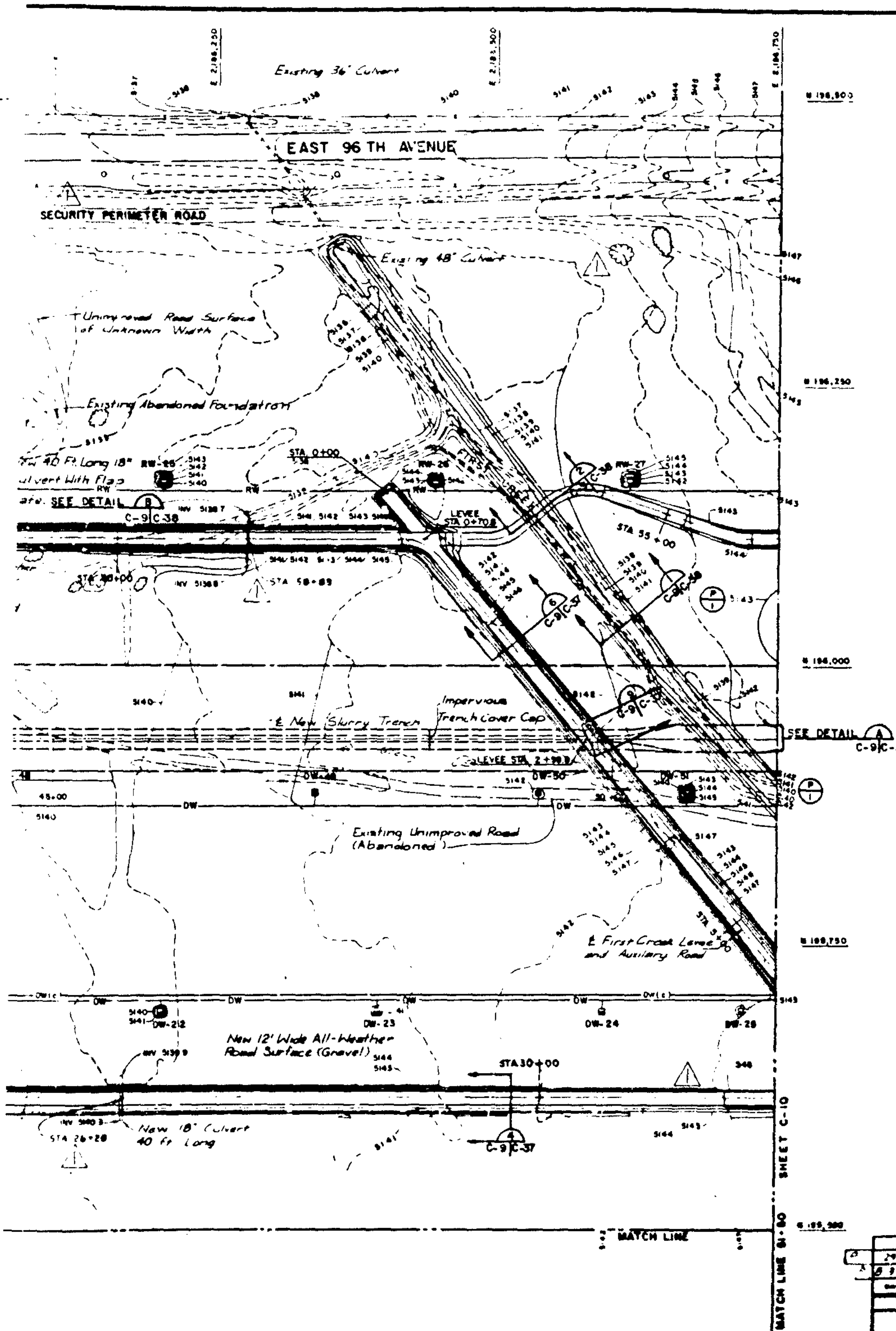
DRAWING NUMBER 71-07-16

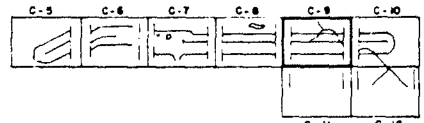
SHEET C-8

$$ - THINK VALUE ENGINEERING - $$



EAST 96
SECURITY PERIMETER ROAD
Existing Trees Typical
Existing Foundation Rubble
Unimproved Road Surface of Unknown Width
Existing Abandoned Foundation
New 40 Ft. Long 18" Culvert With Flap Gate. SEE DETAIL
RW-22
RW-23
RW-24
STA 65+00
STA. 58+89
STA 0+00
New 12' Wide All-Weather Road Surface (Gravel) Alignment of roadway to be field determined
Recommended Limits of Working Surface Area (See sheets C-26 & C-27)
DW-47
DW-19
DW-20
DW-21
STA. 20+00
STA. 25+00
STA 26+28
New 18" Culvert 40 Ft. Long
N 196,500
N 196,250
N 196,000
N 195,750
N 195,500
E 2,185,500
E 2,185,750
E 2,186,000
E 2,186,250
MATCH LINE 39+00 SHEET C-





KEY PLAN

NOTE

ELEVATION OF NEW 12 FT. WIDE ALL-WEATHER ROADWAY TO BE A MINIMUM OF 2 FT. ABOVE EXISTING GRADE.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

29 B	General Revisions		
8 9 83	AM 0001 GENERAL REVISIONS		COB

REVISIONS

BLACK & VEATCH

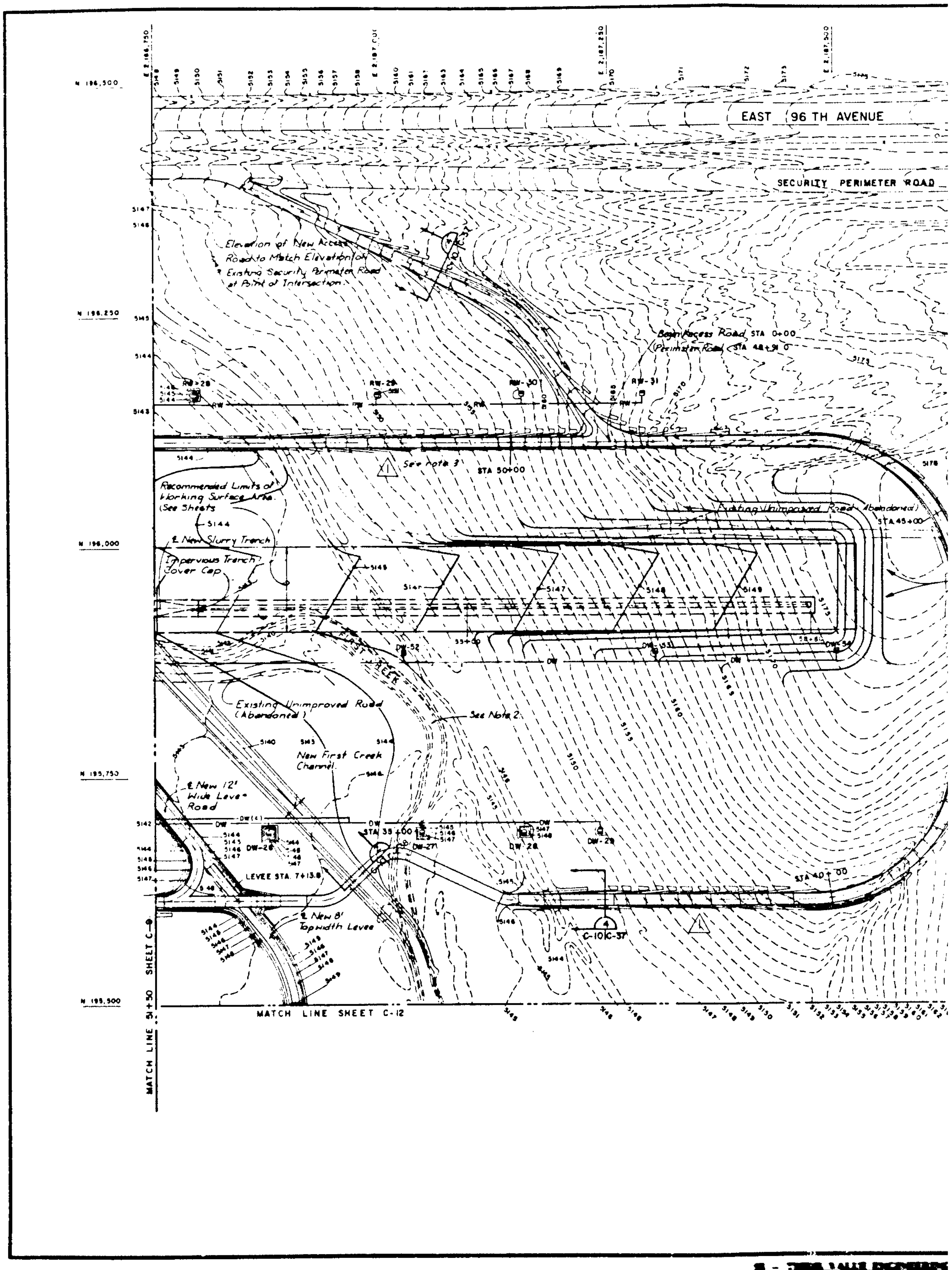
U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

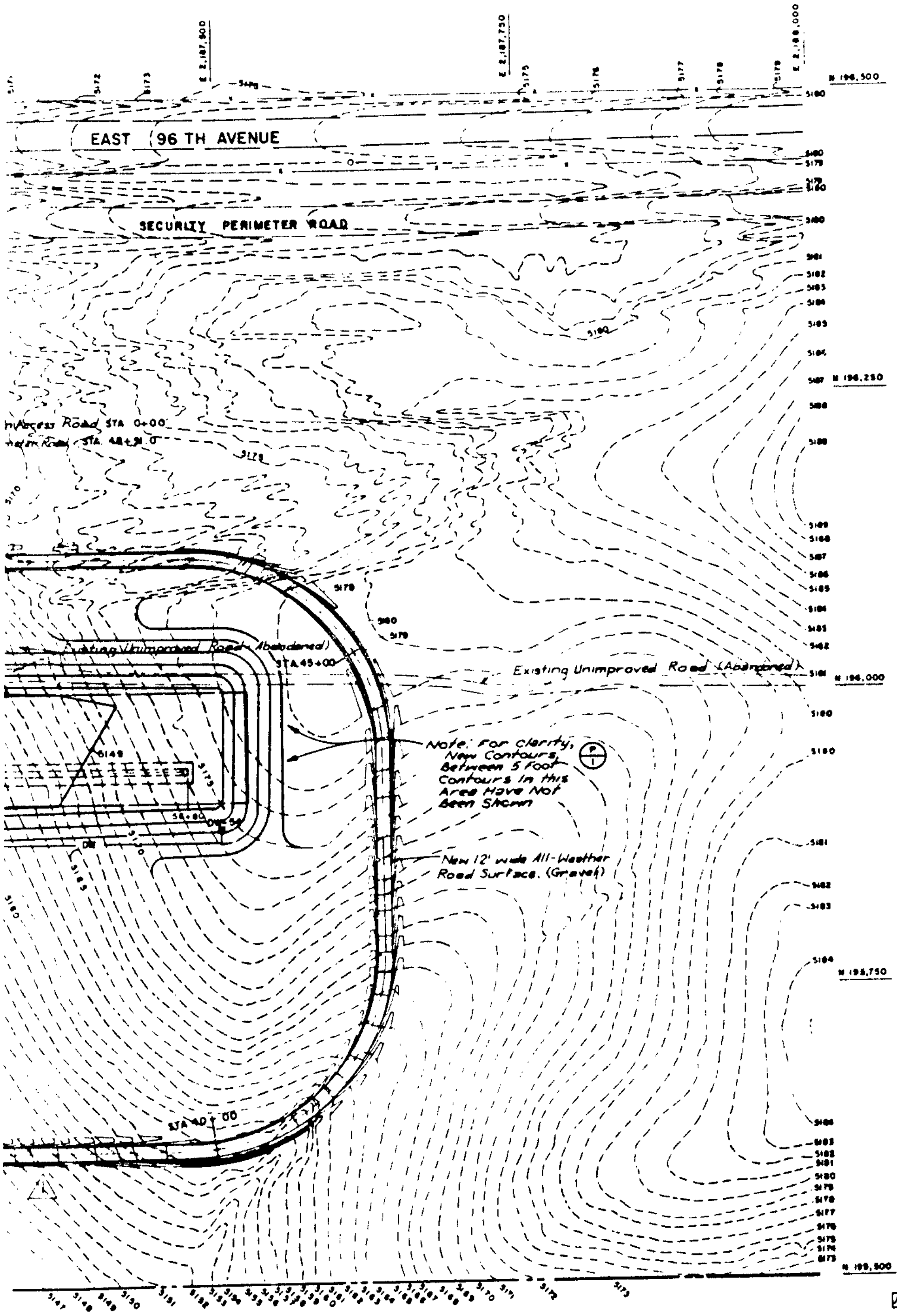
LIQUID WASTE DISPOSAL FACILITY

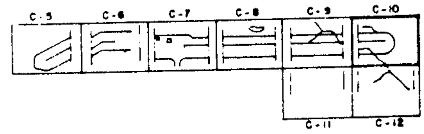
NORTH BOUNDARY EXPANSION

GRADING AND DRAINAGE PLAN

SHEET 5 OF 8


EAST 96 TH AVENUE
SECURITY PERIMETER ROAD
Elevation of New Access Road to Match Elevation of Existing Security Perimeter Road at Point of Intersection
Begin Access Road STA 0+00
(Perimeter Road STA 48+91.0)
See Note 3
STA 50+00
Recommended Limits of Working Surface Area (See Sheets
℄ New Slurry Trench
Impervious Trench Cover Cap
Existing Unimproved Road (Abandoned)
STA 45+00
55+00
Existing Unimproved Road (Abandoned)
See Note 2
New First Creek Channel
℄ New 12' Wide Levee Road
LEVEE STA. 7+13.8
℄ New 8' Topwidth Levee
STA 35+00
STA 40+00
N 196,500
N 196,250
N 196,000
N 195,750
N 195,500
E 2,186,750
E 2,187,000
E 2,187,250
E 2,187,500
MATCH LINE SHEET C-12
MATCH LINE 51+50 SHEET C-9





KEY PLAN

NOTES:

1. ELEVATION OF NEW 12 FT. WIDE ALL-WEATHER ROADWAY TO BE A MINIMUM OF 2 FT. ABOVE EXISTING GRADE.
2. EXISTING (ABANDONED) FIRST CREEK CHANNEL TO BE BACKFILLED TO TOP OF BANKS.
3. CONTRACTOR TO REMOVE DOWNED TIMBER WITHIN LIMITS OF WORKING AREA

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

	DATE	DESCRIPTION	MADE	APPR
P-1	1.29.81	Changed Contours Surface over Slurry Trench		C.O.B.
1	8.13.80	AM #0001 GENERAL REVISIONS		C.O.B

REVISIONS

BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

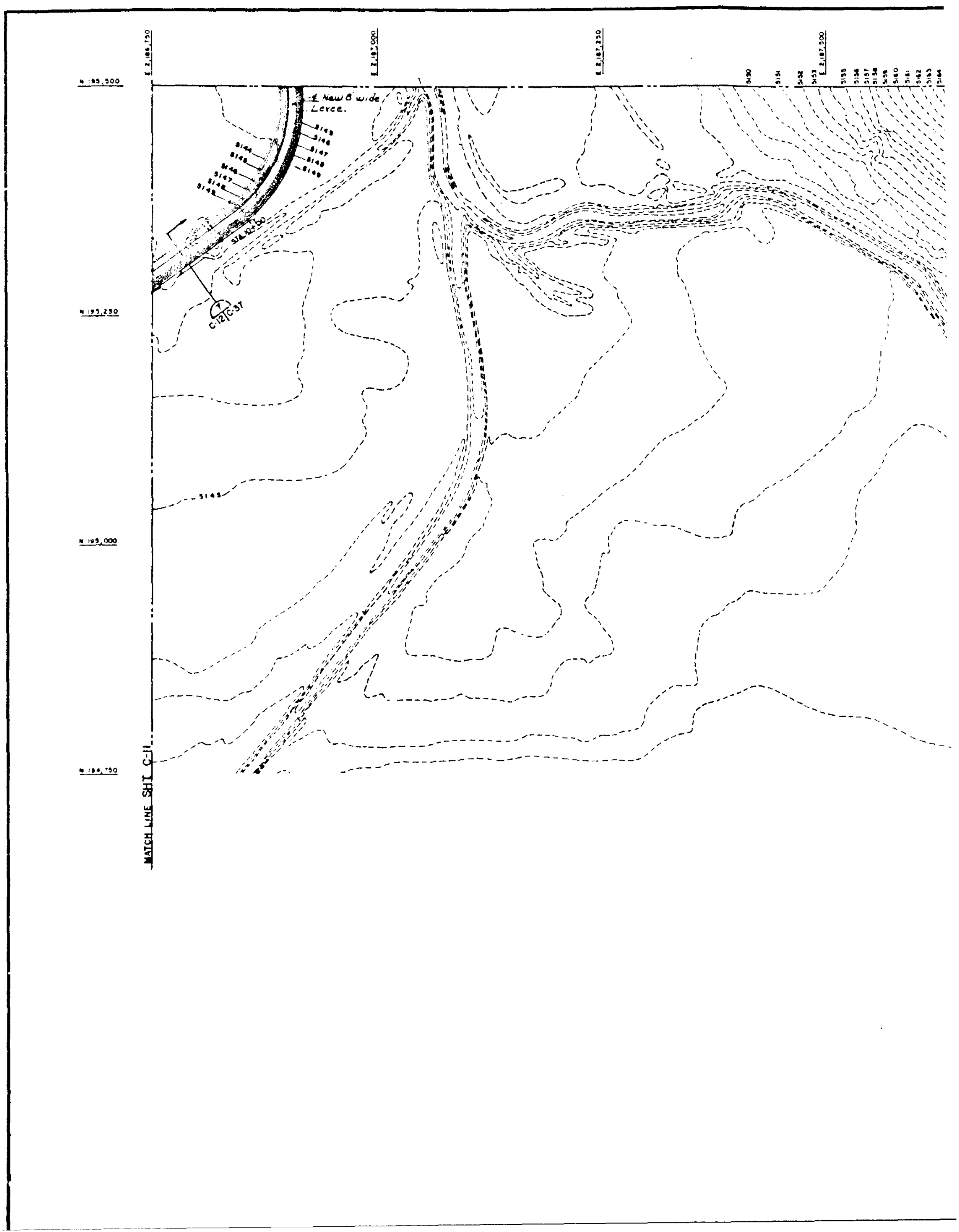
D.A.D. / V.M.R.
M.H.M.
J.E.R.

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GRADING AND DRAINAGE PLAN
SHEET 6 OF 6

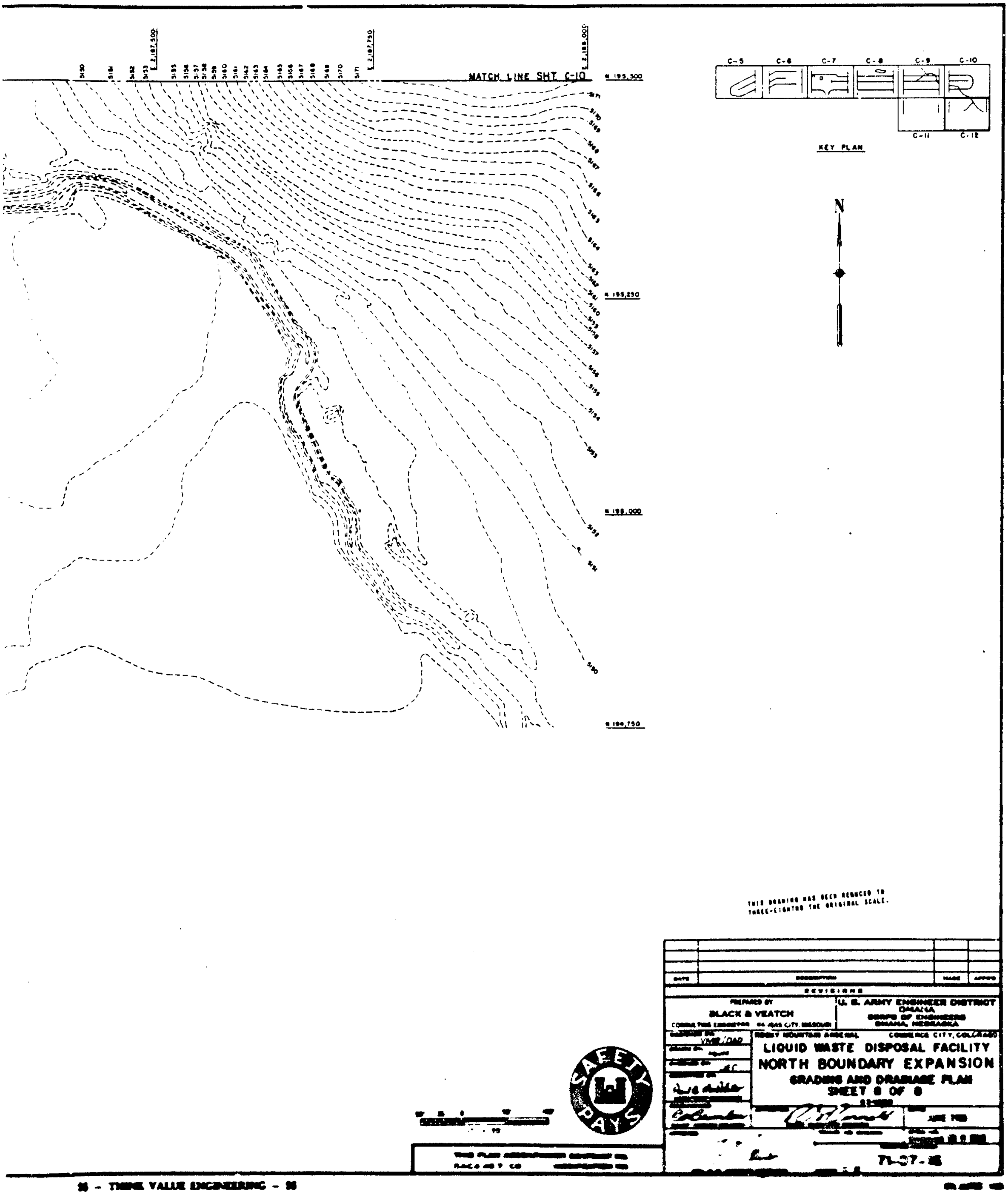
JUNE 1979

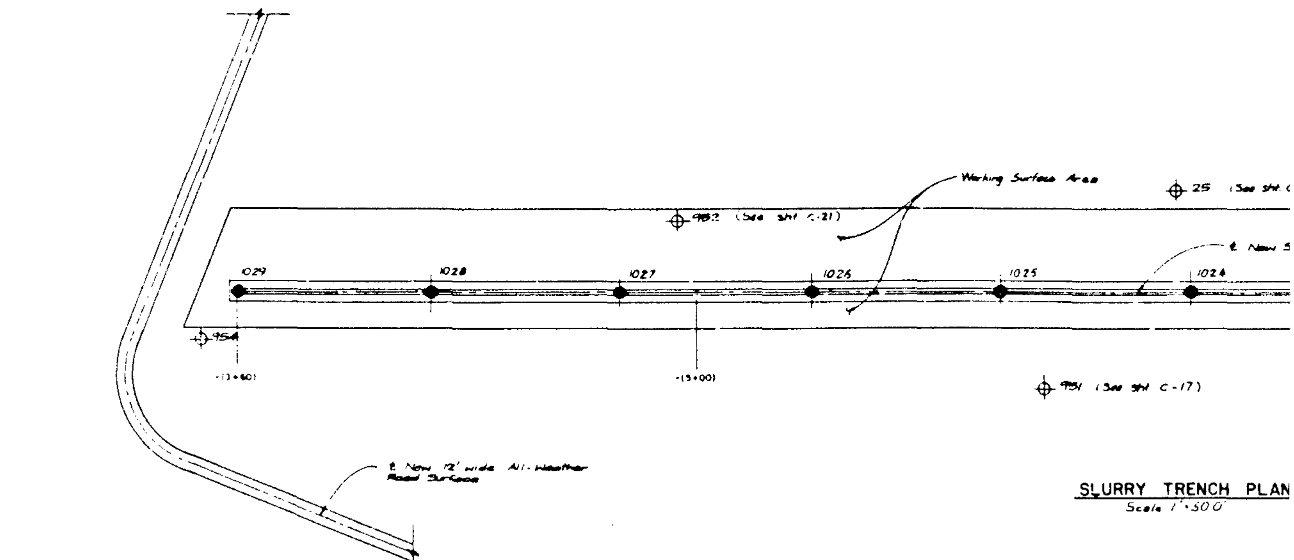
71-07-16

PLATE 1

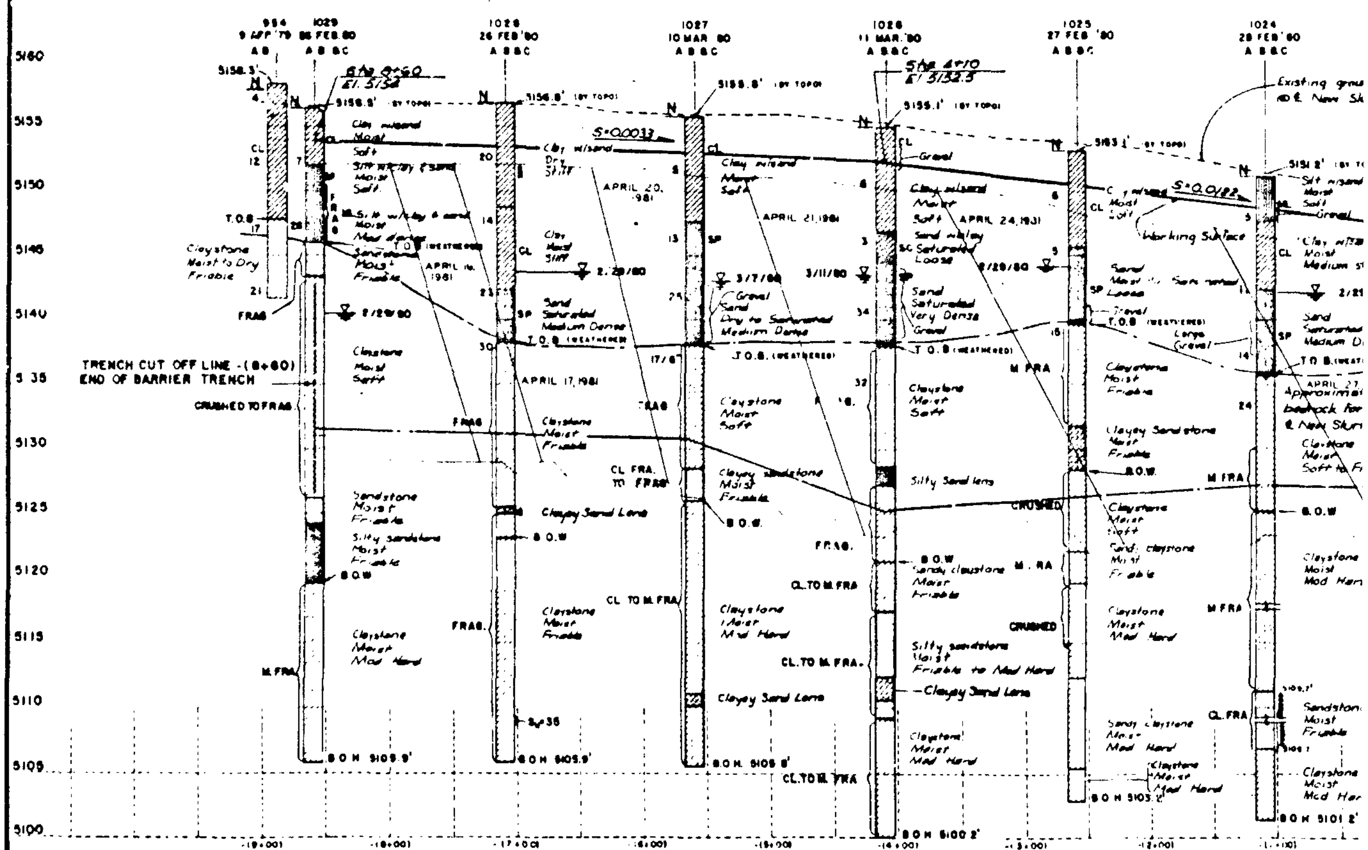


N 195,500
N 195,250
N 195,000
N 194,750
E 2,186,750
E 2,187,000
E 2,187,250
E 2,187,500
¢ New 8' wide Levee.
STA 10+00
C-12
C-37
5145
MATCH LINE SHT C-11
5150
5151
5152
5153
5155
5156
5157
5158
5160
5161
5162
5163
5164


MATCH LINE SHT C-10
N 195,500
N 195,250
N 195,000
N 194,750
E 2,187,500
E 2,187,750
E 2,188,000
C-5
C-6
C-7
C-8
C-9
C-10
C-11
C-12
KEY PLAN
N
THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.
REVISIONS
BLACK & VEATCH
U. S. ARMY ENGINEER DISTRICT
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GRADING AND DRAINAGE PLAN
SAFETY PAYS



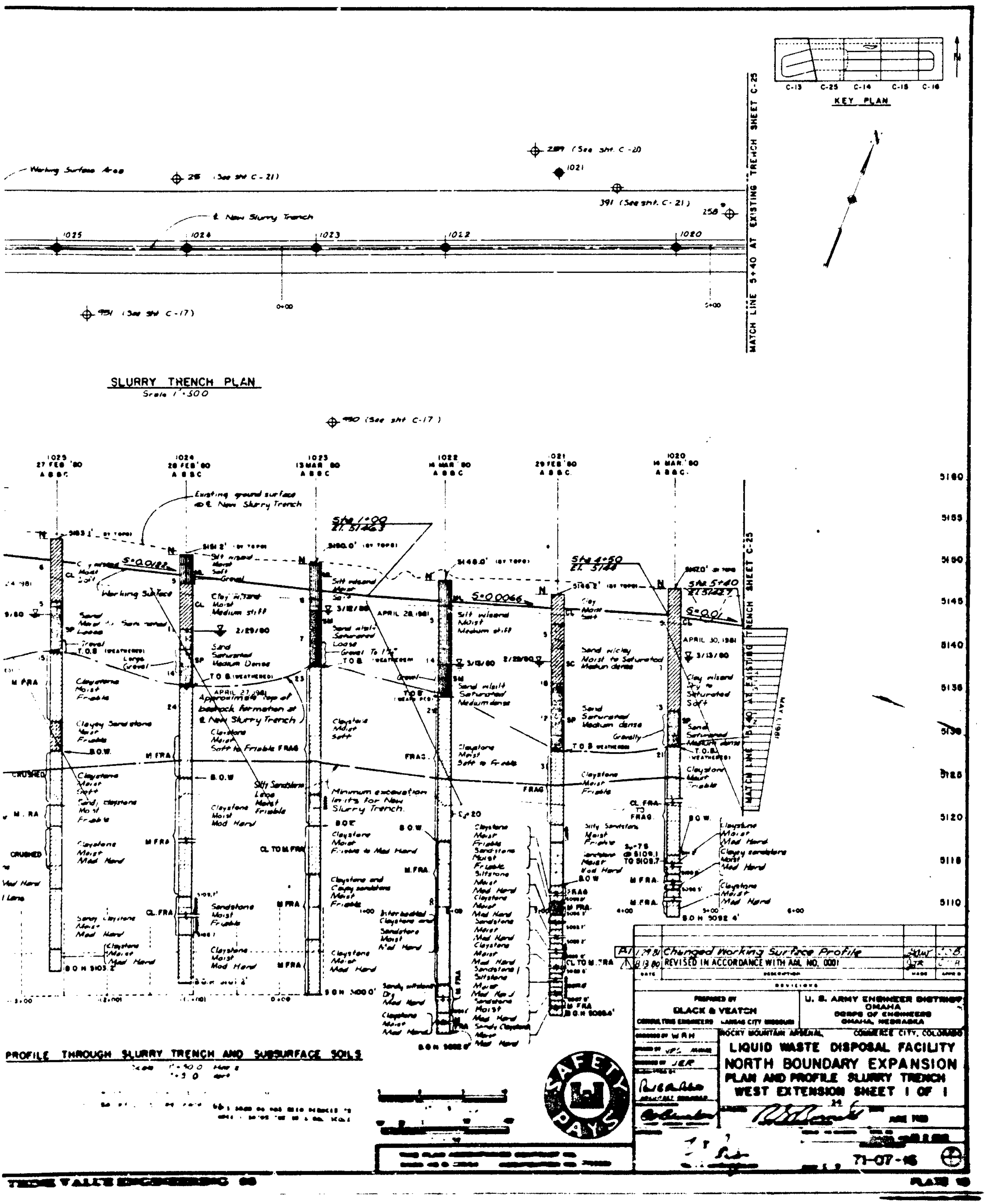
SLURRY TRENCH PLAN
Scale 1"=50'



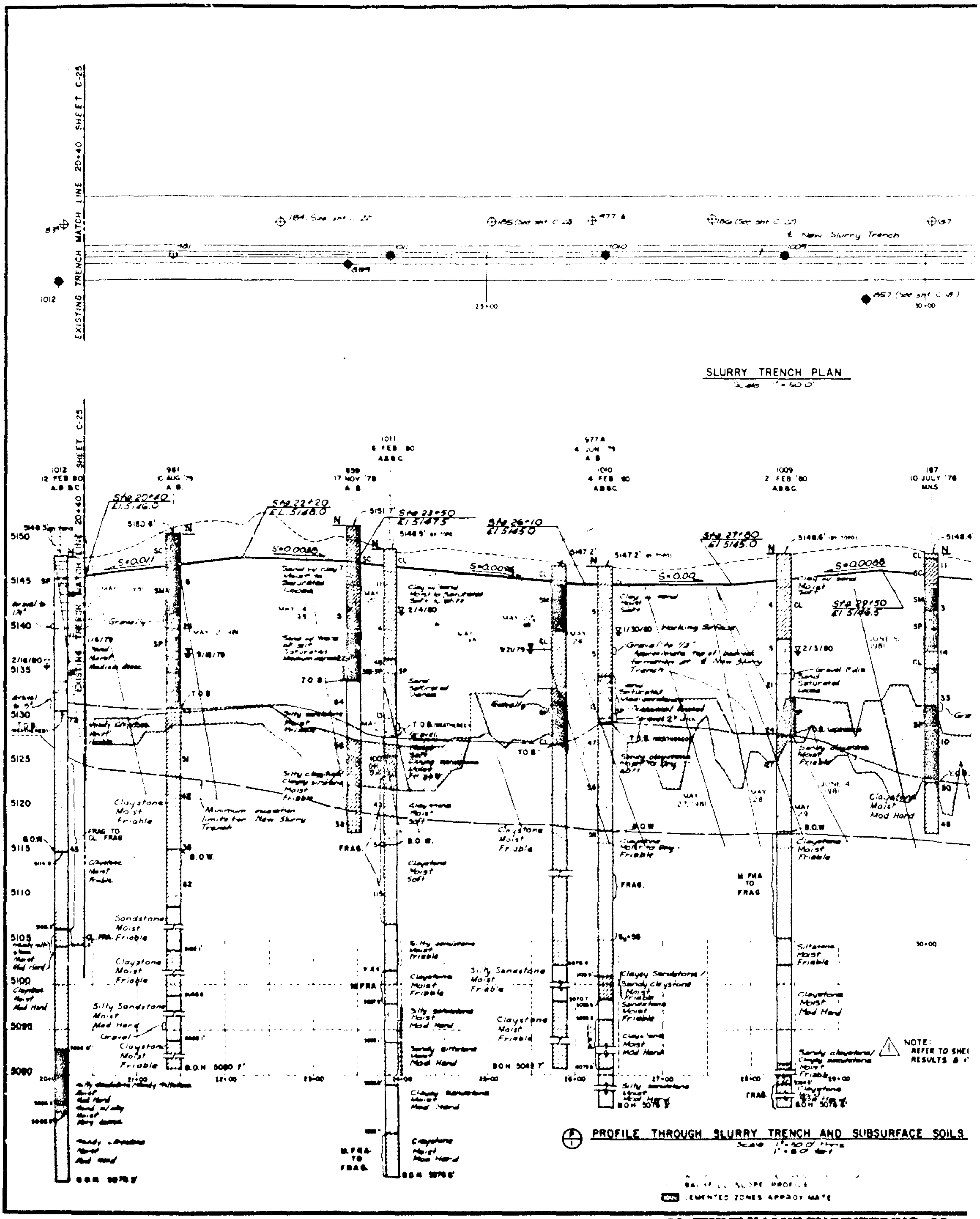
PROFILE THROUGH SLURRY TRENCH AND

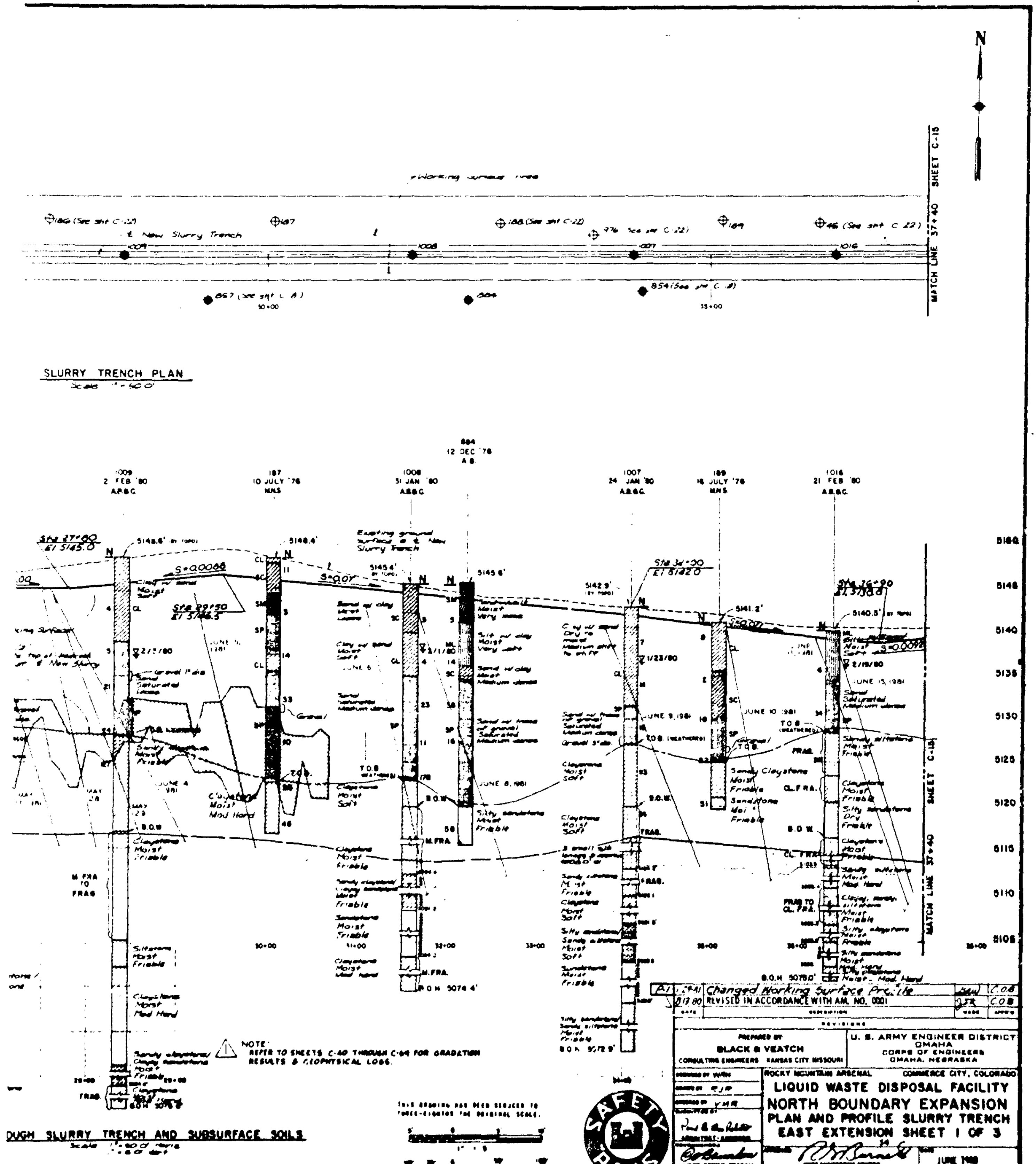
NOTES:

1. WELL STATIONS BASED ON SLURRY TRENCH ℄ STATIONS
2. REFER TO SHEETS C-60 THROUGH C-64 FOR GRADATION RESULTS & GEOPHYSICAL LOGS



KEY PLAN
C-13 C-25 C-14 C-15 C-16
MATCH LINE 5+40 AT EXISTING TRENCH SHEET C-25
Working Surface Area
℄ New Slurry Trench
1025
1024
1023
1022
1021
1020
SLURRY TRENCH PLAN
Existing ground surface @ ℄ New Slurry Trench
Working Surface
Approximate top of bedrock formation at ℄ New Slurry Trench
Minimum excavation limits for New Slurry Trench
Sta 1+00 El. 5146.3
Sta 4+50 El. 5144
Sta 5+40 El. 5142.7
S=0.0066
S=0.01
APRIL 27, 1981
APRIL 28, 1981
APRIL 30, 1981
5160
5155
5150
5145
5140
5135
5130
5125
5120
5115
5110
PROFILE THROUGH SLURRY TRENCH AND SUBSURFACE SOILS
Changed Working Surface Profile
REVISED IN ACCORDANCE WITH AM. NO. 0001
PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY MISSOURI
U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE SLURRY TRENCH
WEST EXTENSION SHEET 1 OF 1
71-07-16
SAFETY PAYS
PLATE 16


EXISTING TRENCH MATCH LINE 20+40 SHEET C-25
New Slurry Trench
25+00
30+00
SLURRY TRENCH PLAN
1012
12 FEB 80
981
10 AUG '79
1011
6 FEB '80
850
17 NOV '78
977 A
4 JUN '79
1010
4 FEB '80
1009
2 FEB '80
187
10 JULY '76
Sta 20+40
El 5146.0
Sta 22+20
EL 5148.0
Sta 23+50
El 5147.5
Sta 26+10
El 5145.0
Sta 27+80
El 5145.0
Sta 29+50
El 5146.5
S=0.011
S=0.0086
S=0.0096
S=0.00
S=0.0088
5150
5145
5140
5135
5130
5125
5120
5115
5110
5105
5100
5095
5090
T.O.B.
B.O.W.
FRAG.
Claystone
Moist
Friable
Minimum excavation limits for New Slurry Trench
Sandstone
Moist
Friable
Silty Sandstone
Moist
Mod Hard
Clayey Sandstone
Moist
Mod Hard
NOTE:
REFER TO SHEET
RESULTS
PROFILE THROUGH SLURRY TRENCH AND SUBSURFACE SOILS
CEMENTED ZONES APPROXIMATE



PROFILE THROUGH SLURRY TRENCH AND SUBSURFACE SOILS

A1	1-29-81	Changed Working Surface Profile	C.O.B.
	6-13-80	REVISED IN ACCORDANCE WITH AM. NO. 0001	C.O.B.
DATE		DESCRIPTION	APPR'D

REVISIONS

PREPARED BY: BLACK & VEATCH, CONSULTING ENGINEERS, KANSAS CITY, MISSOURI

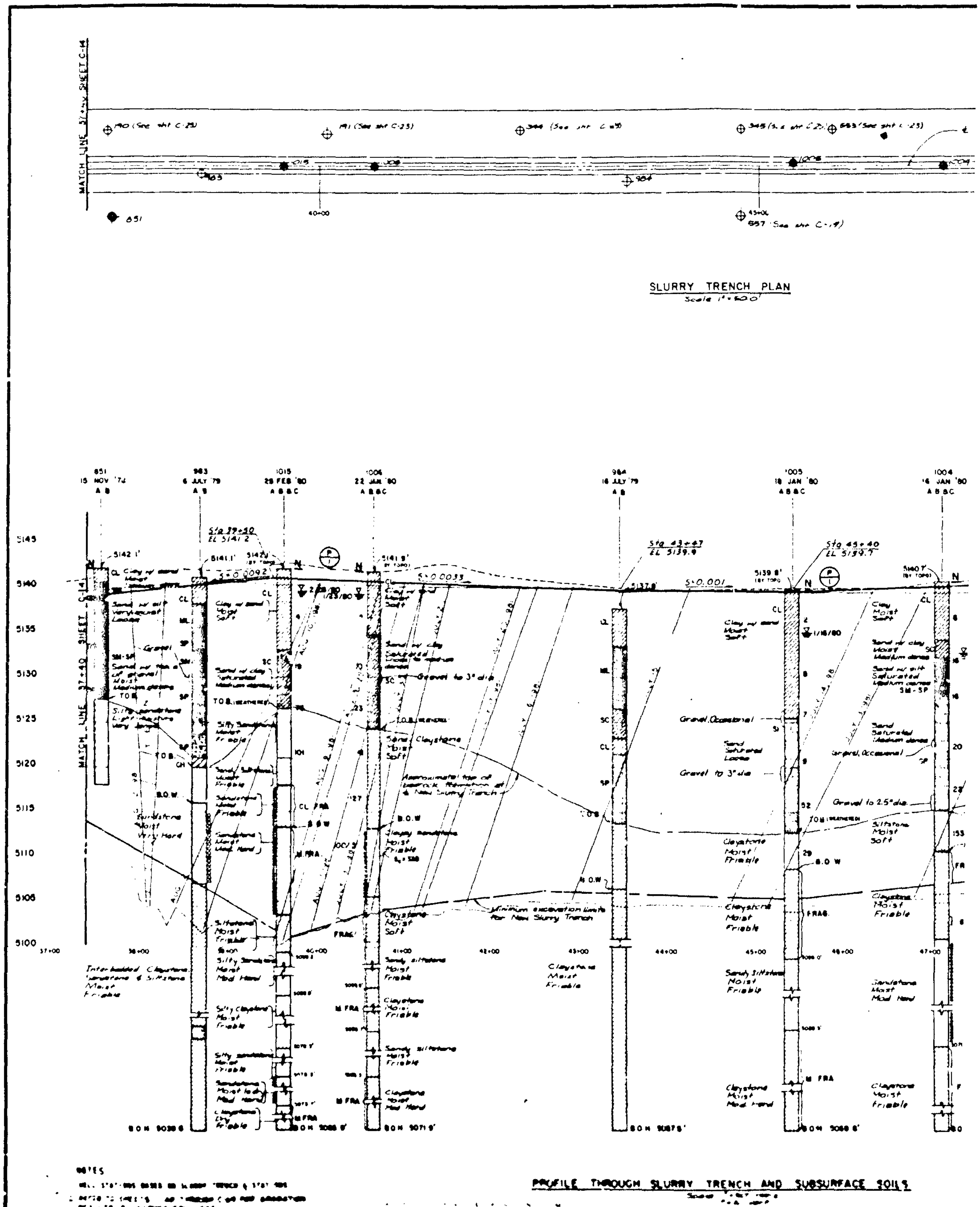
U. S. ARMY ENGINEER DISTRICT, OMAHA, CORPS OF ENGINEERS, OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

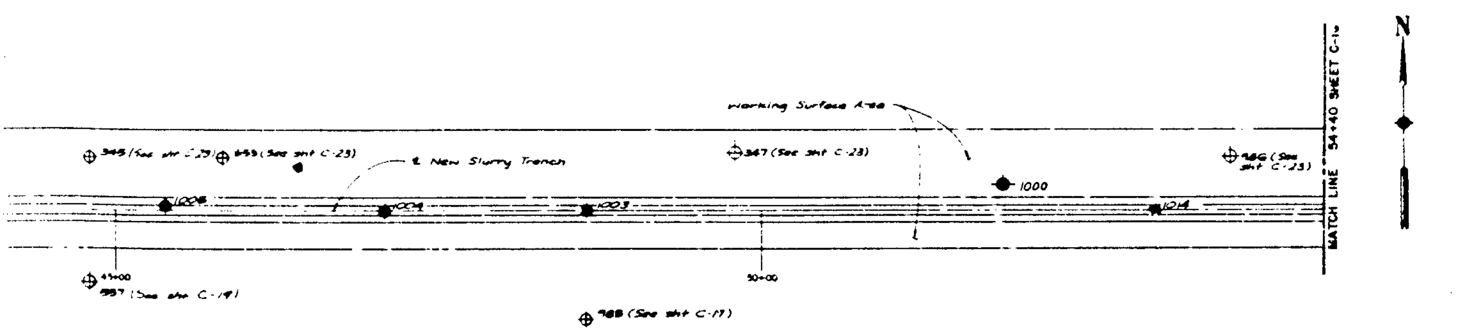
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE SLURRY TRENCH
EAST EXTENSION SHEET 1 OF 3

JUNE 1980

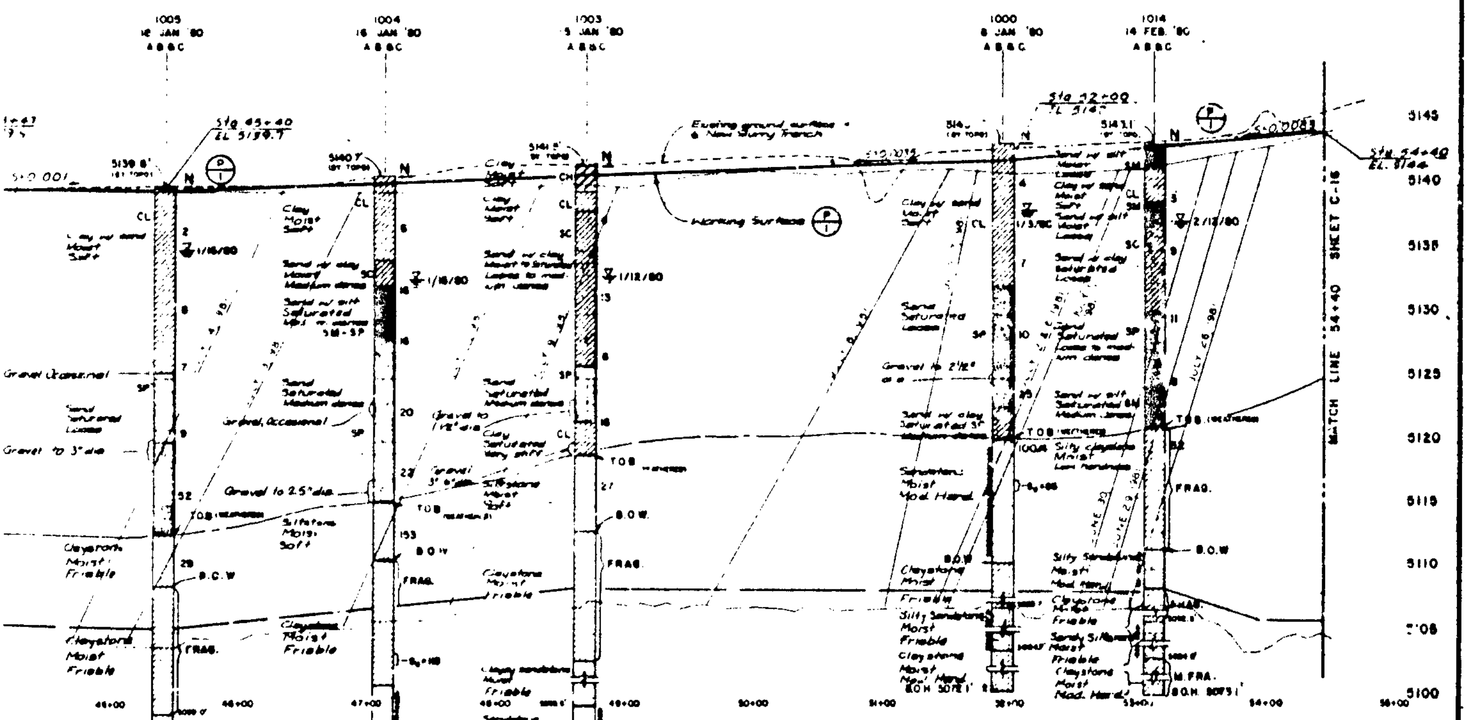
71-07-16



SLURRY TRENCH PLAN
PROFILE THROUGH SLURRY TRENCH AND SUBSURFACE SOILS
NOTES



RY TRENCH PLAN



TY TRENCH AND SUBSURFACE SOILS

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

P	1-29-81	Revised working surface		
△	8-19-80	REVISED IN ACCORDANCE WITH AM. NO. 0001		
DATE		DESCRIPTION		

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

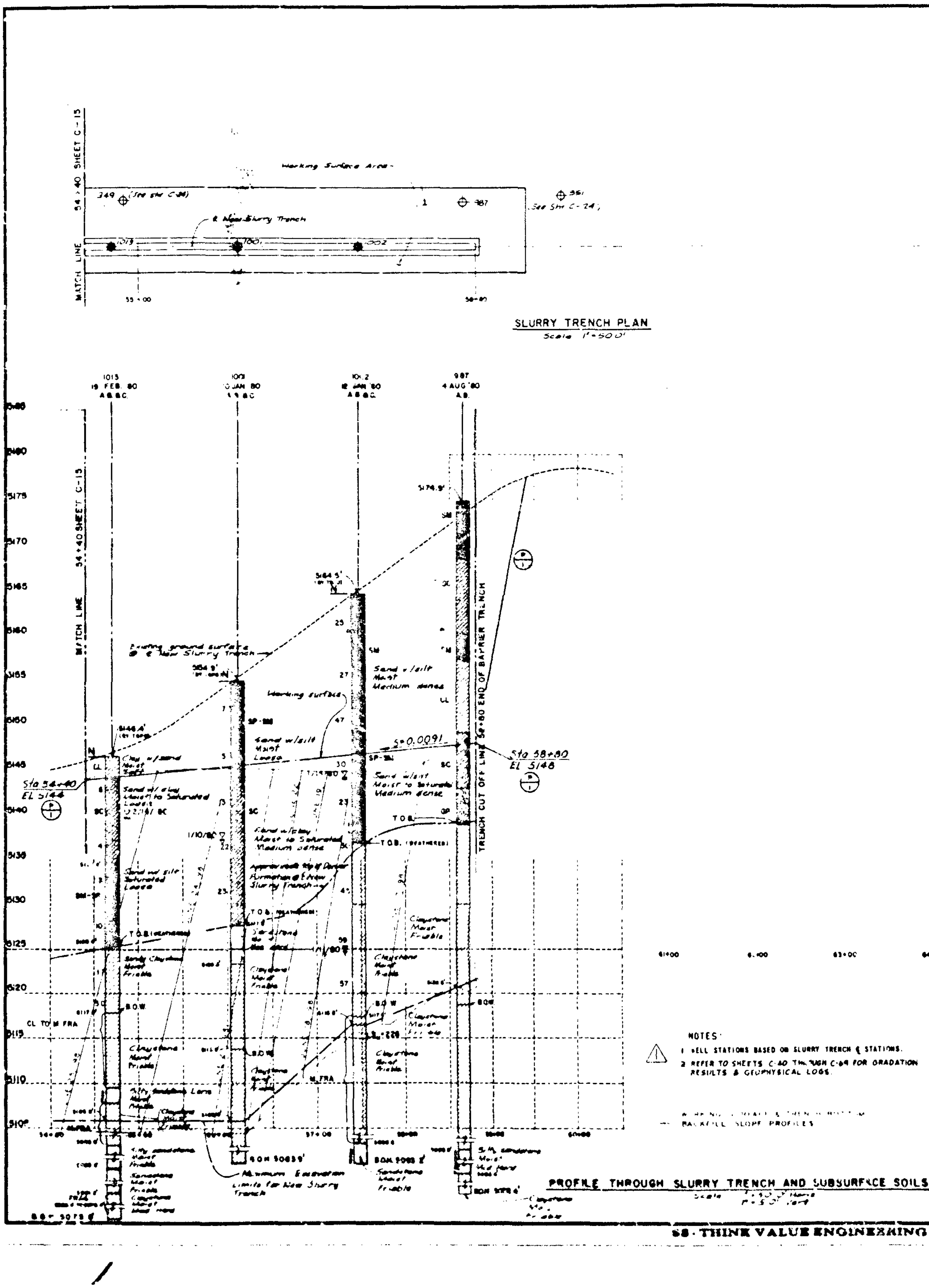
DESIGNED BY WRH
DRAWN BY KJR
CHECKED BY VMK

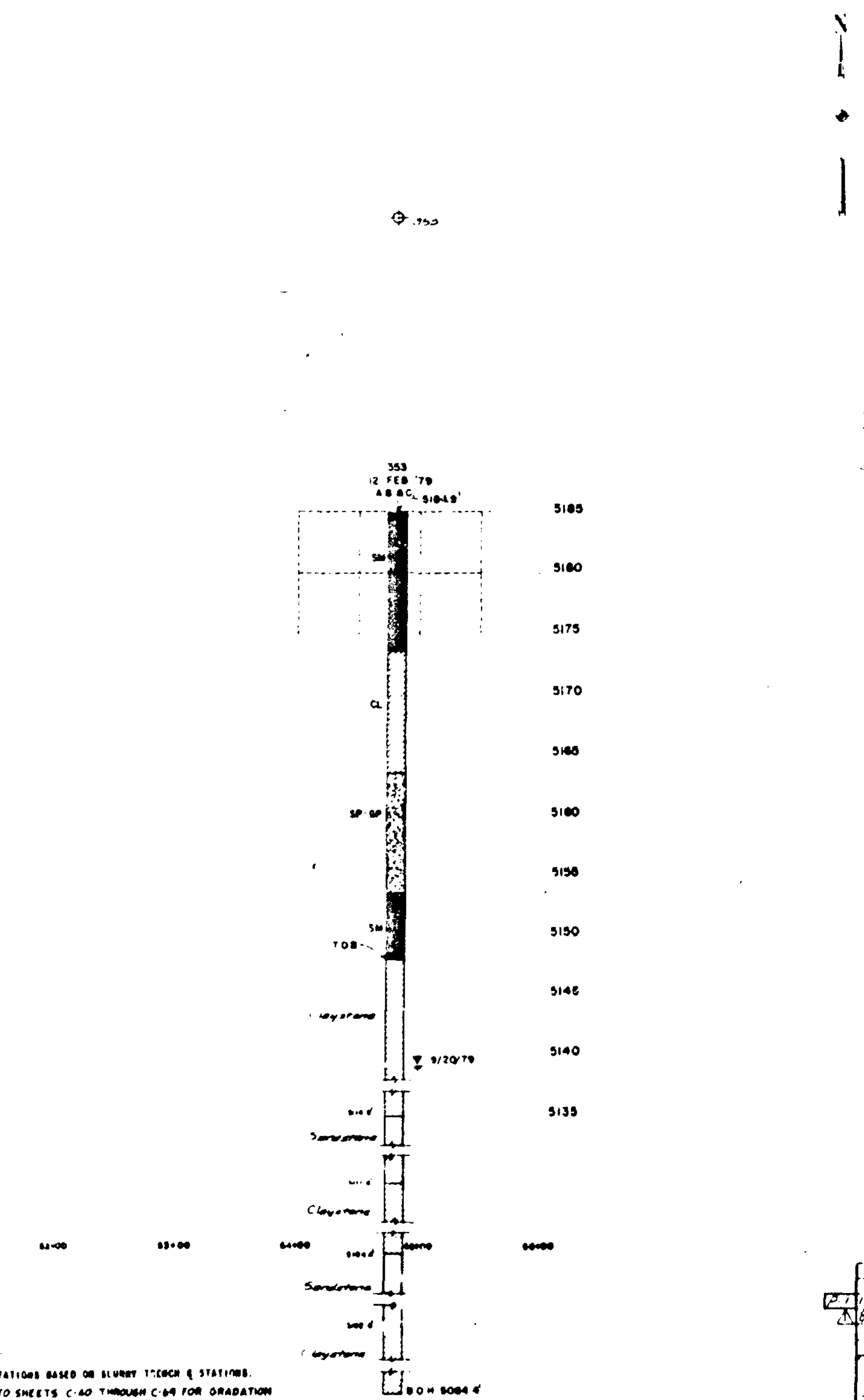
ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE SLURRY TRENCH
EAST EXTENSION SHEET 2 OF 3

JUNE 1980

71-07-16


SLURRY TRENCH PLAN
MATCH LINE 54+40 SHEET C-15
Working Surface Area
TRENCH CUT OFF LINE 58+80 END OF BARRIER TRENCH
Sta 54+40
EL 5144
Sta 58+80
EL 5148
S=0.0091
T.O.B.
B.O.W.
Sand w/silt
Moist
Medium dense
Claystone
Moist
Friable
Minimum Excavation
Limits for New Slurry
Trench
NOTES:
1 WELL STATIONS BASED ON SLURRY TRENCH ℄ STATIONS.
2 REFER TO SHEETS C-40 THROUGH C-64 FOR GRADATION RESULTS & GEOPHYSICAL LOGS.
BACKFILL SLOPE PROFILES
PROFILE THROUGH SLURRY TRENCH AND SUBSURFACE SOILS



NOTES:

WELL STATIONS BASED ON SLURRY TRENCH ℄ STATIONS.

REFER TO SHEETS C-40 THROUGH C-69 FOR GRADATION RESULTS & GEOPHYSICAL LOGS

SLOPE PROFILES

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

URRY TRENCH AND SUBSURFACE SOILS

P-1	1-19-81	Revised working surface	HRN	C.O.B.
1	8-11-80	REVISED IN ACCORDANCE WITH AM. NO. 0001		C.O.B.
DATE		DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

DESIGNED BY HRN
DRAWN BY HLE
CHECKED BY JER

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE SLURRY TRENCH
EAST EXTENSION SHEET 3 OF 3

DATE JUNE 1980

SCALE AS SHOWN

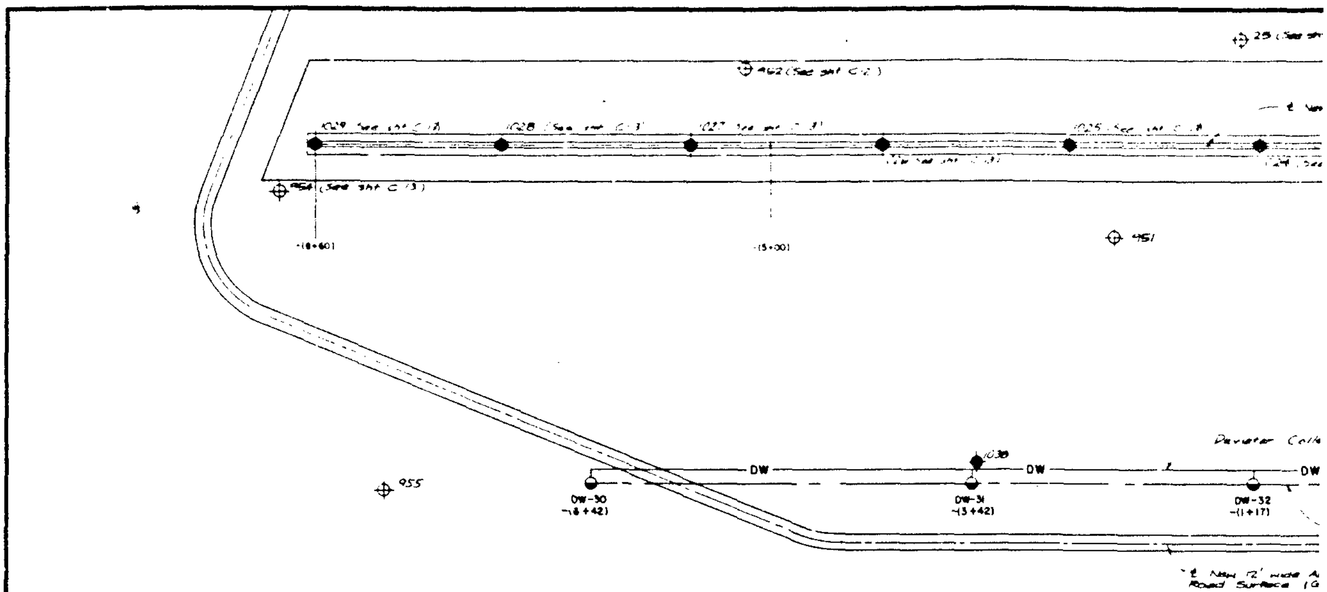
71-07-16

PLATE 30

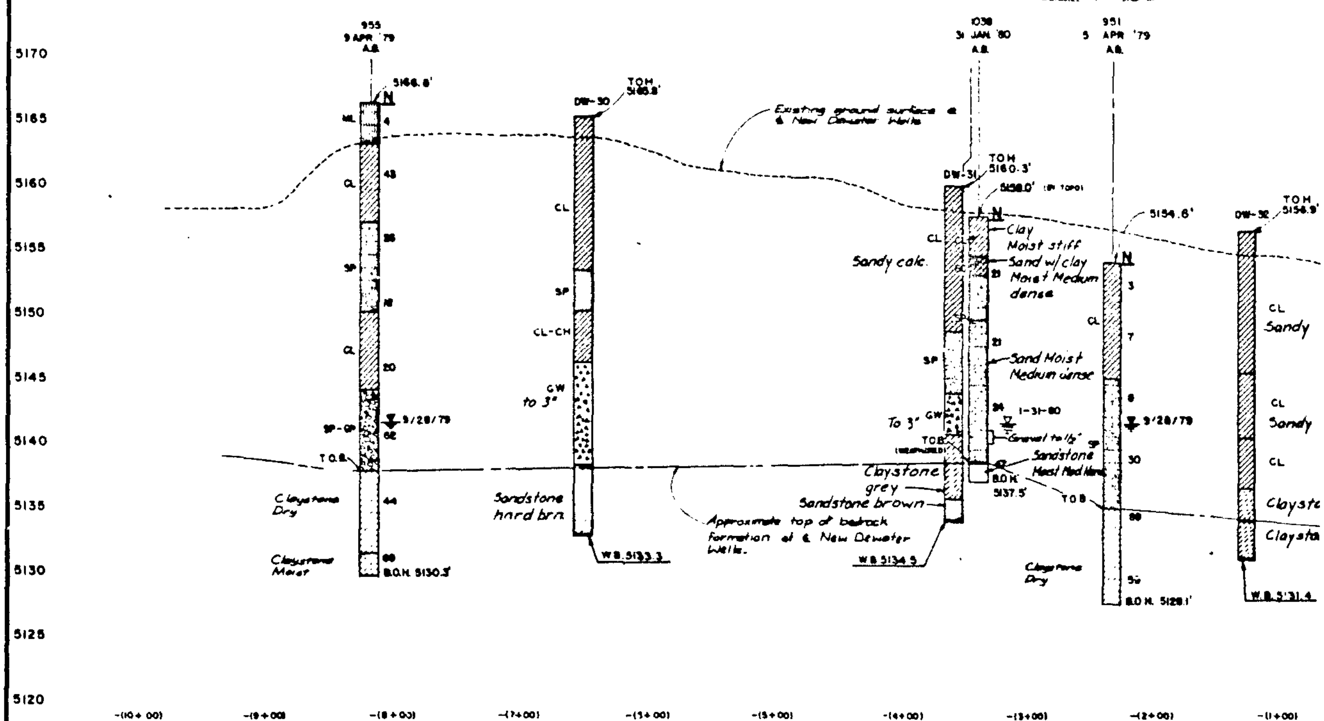
THIS PLAN ACCOMPANIES SPECIFICATION NO. DACA 45-81-C-0034

· THINK VALUE ENGINEERING · 66

2

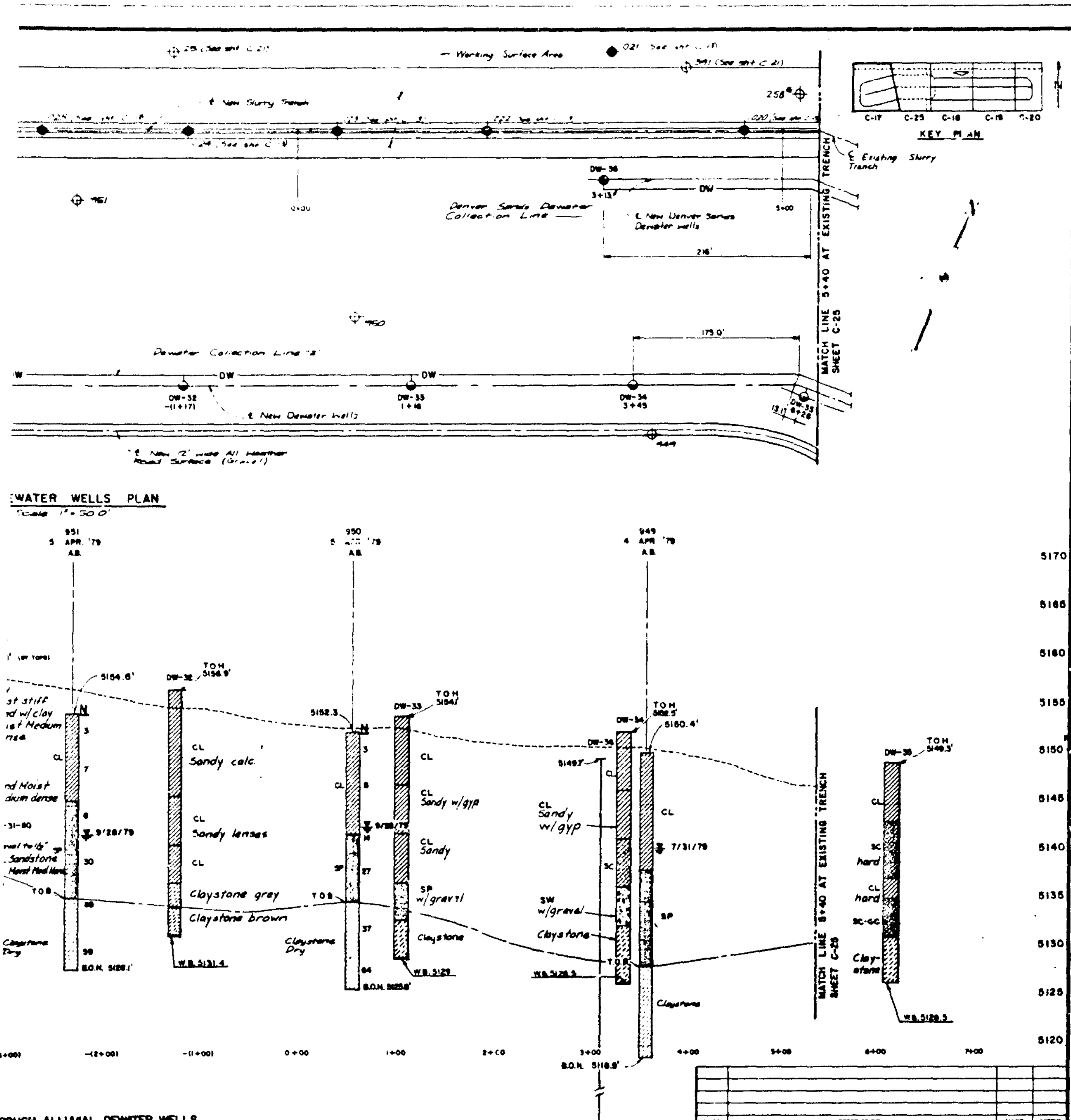


DEWATER WELLS PLAN
Scale 1" = 50.0'



NOTE:
WELL STATIONS BASED ON SLURRY TRENCH ℄ STATIONS

PROFILE THROUGH ALLUVIAL DEWATER WELLS
Scale: 1" = 50.0' Horiz
1" = 5.0' Vert



DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

DESIGNED BY WRH
DRAWN BY VPB/RJR
CHECKED BY JER
SUBMITTED BY ARCHITECT-ENGINEER
RECOMMENDED CHIEF DESIGN BRANCH
APPROVED

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

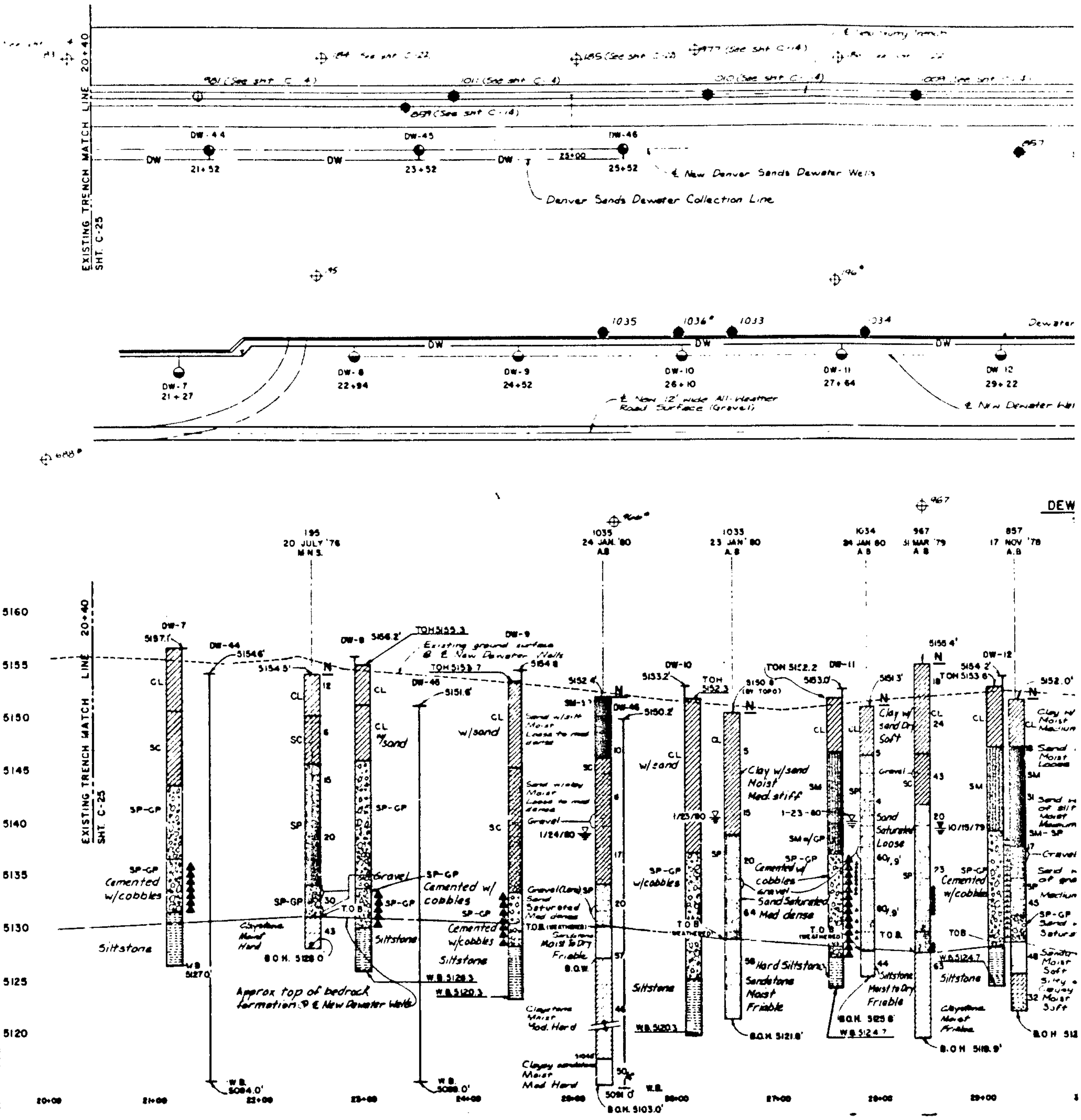
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE DEWATER WELLS
WEST EXTENSION. SHEET 1 OF 1

34

DATE: JUNE 1980
SCALE: AS SHOWN
SPEC. NO. DACA 45-80-R-0161
DRAWING NUMBER 71-07-16
SHEET C-17

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 — MODIFICATION NO.

PLATE 91

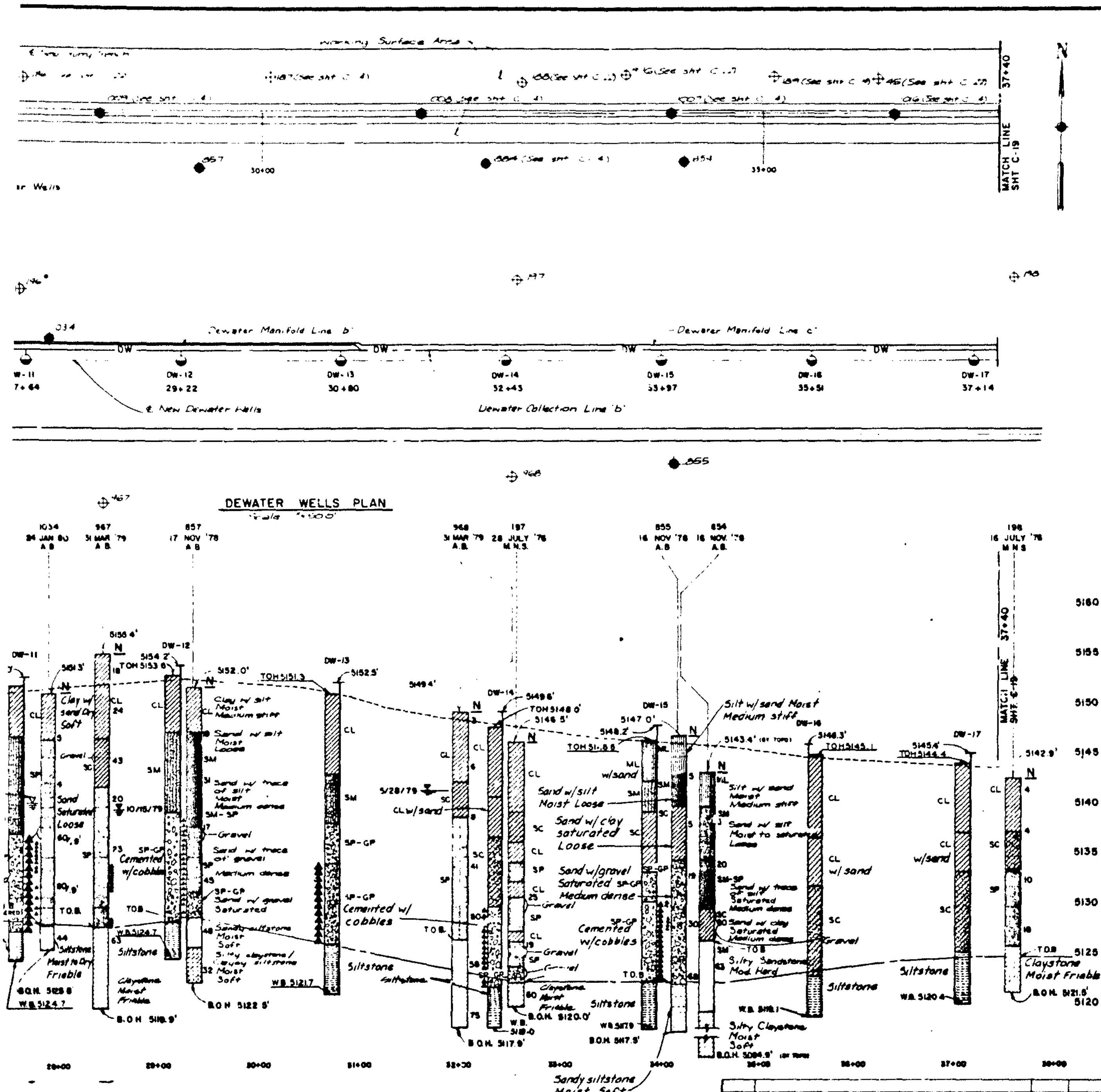


NOTE

WELL STATIONS BASED ON SLURRY TRENCH ℄ STATIONS

PROFILE THROUGH A

Scale



PROFILE THROUGH ALLUVIAL DEWATER WELLS

Scale: 1" = 50' Horiz
1" = 6.0' Vert

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

1" = 5'

1" = 50'

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 MODIFICATION NO.

DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

DESIGNED BY WRH

DRAWN BY

CHECKED BY VMR

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION PLAN AND PROFILE DEWATER WELLS EAST EXTENSION SHEET 1 OF 3

34

JUNE 1980

SCALE AS SHOWN

DACA 45 80 R 0161

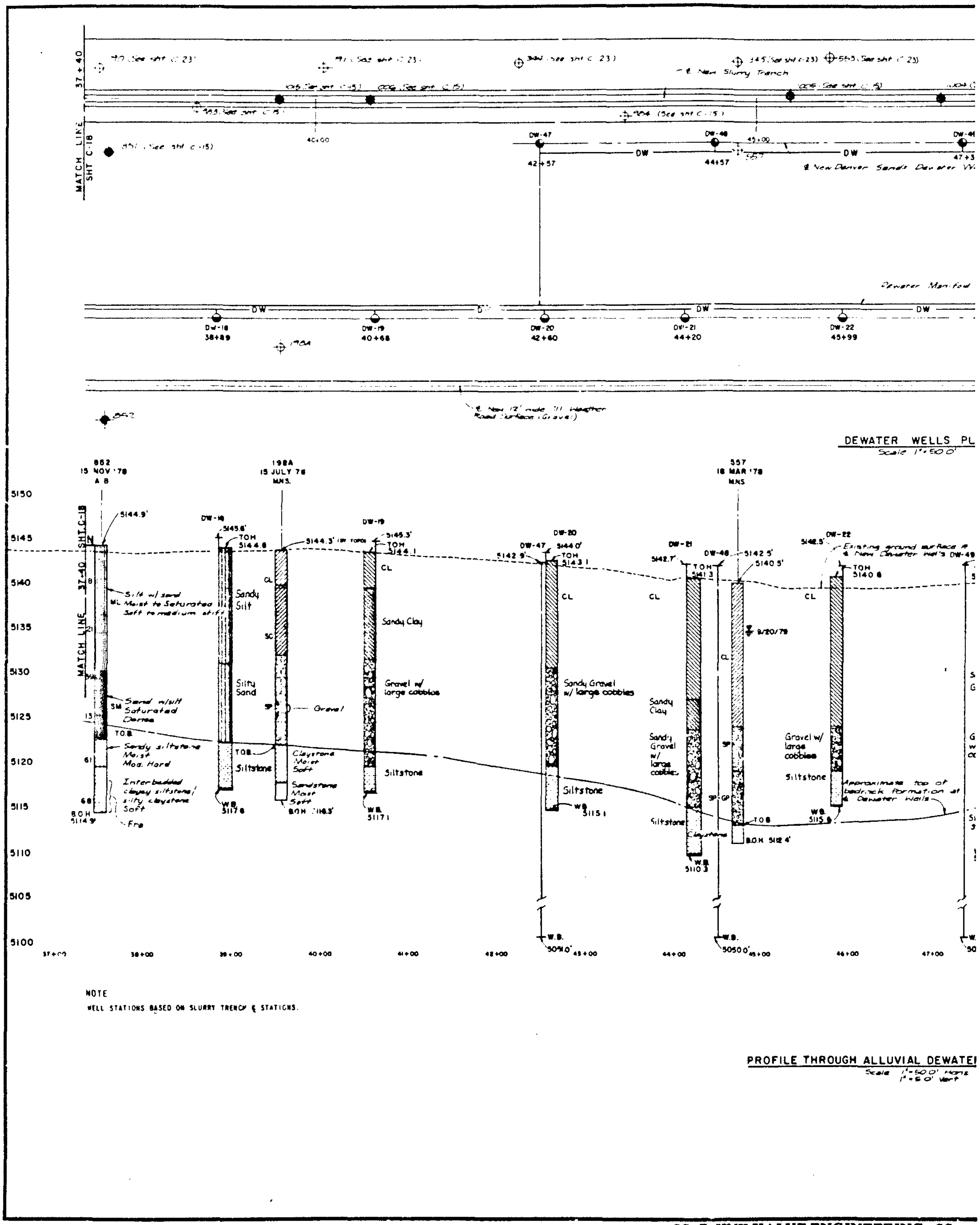
71-07-16

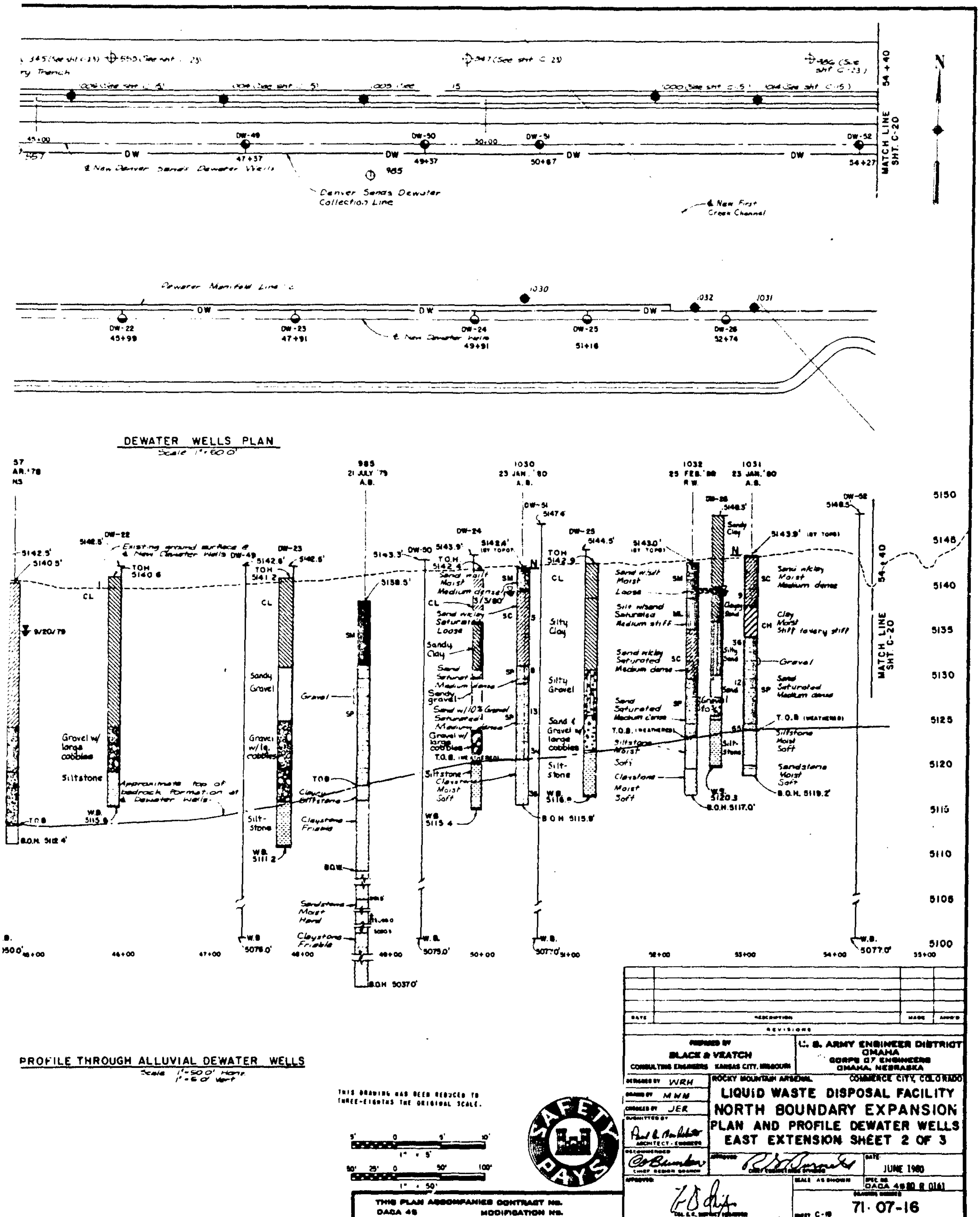
SHEET C-18

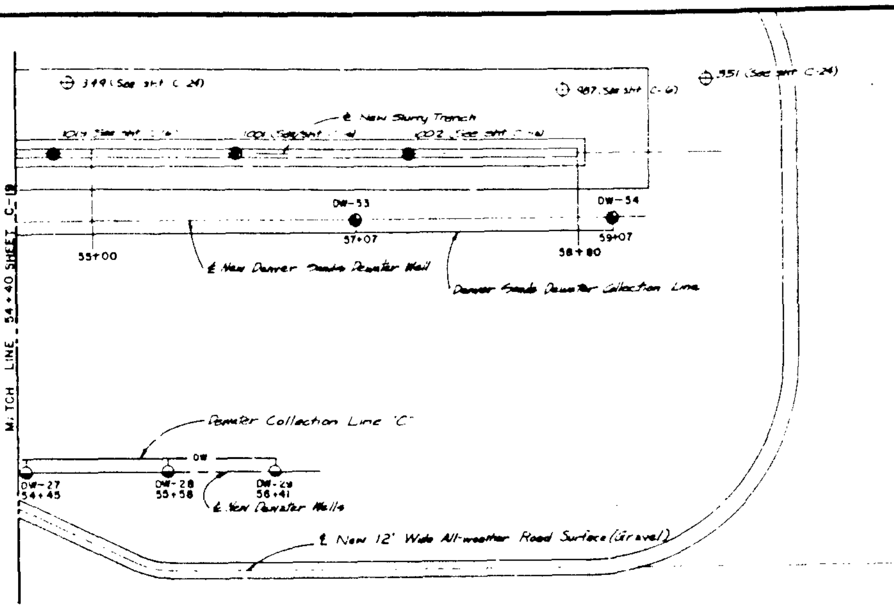
THINK VALUE ENGINEERING - $$

PLATE 32

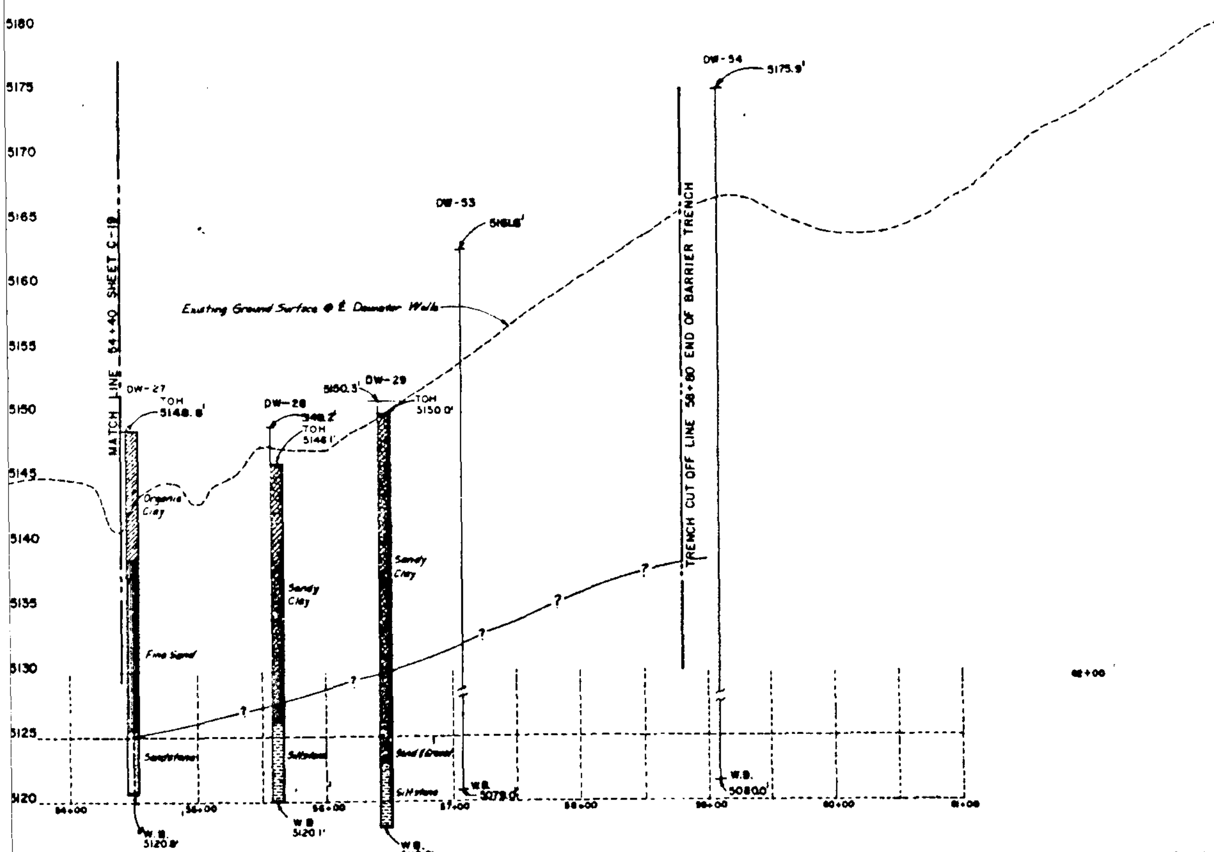
2


DEWATER WELLS PL
Scale 1"=50.0'
MATCH LINE SHT C-18
37+40
New Slurry Trench
DW-47
42+57
DW-48
44+57
DW
New Denver Sands Dewater W
Dewater Manifold
DW-18
38+89
DW-19
40+68
DW-20
42+60
DW-21
44+20
DW-22
45+99
New 12' wide Weather Road Surface (Gravel)
862
15 NOV '78
198A
15 JULY 76
557
18 MAR '78
5150
5145
5140
5135
5130
5125
5120
5115
5110
5105
5100
Silt w/ sand
Moist to Saturated
Soft to medium stiff
Sandy Silt
Silty Sand
Sandy Clay
Gravel w/ large cobbles
Sandy Gravel w/ large cobbles
Sand w/silt
Saturated
Dense
Sandy siltstone
Moist
Mod. Hard
Interbedded clayey siltstone/ silty claystone
Soft
Siltstone
Claystone
Moist
Soft
Sandstone
Moist
Soft
Gravel
Sandy Clay
Sandy Gravel w/ large cobbles
Gravel w/ large cobbles
Existing ground surface @ New Dewater Well's
Approximate top of bedrock formation at Dewater Wells
TOH
TOB
BOH
W.B.
CL
SC
SP
9/20/79
NOTE
WELL STATIONS BASED ON SLURRY TRENCH STATIONS.
PROFILE THROUGH ALLUVIAL DEWATE
Scale 1"=50.0' Horiz
1"=5.0' Vert


DEWATER WELLS PLAN
Scale 1"=60.0'
PROFILE THROUGH ALLUVIAL DEWATER WELLS
Scale 1"=50.0' Horz. 1"=5.0' Vert
Denver Sands Dewater Collection Line
Dewater Manifold Line
MATCH LINE SHT. C-20
THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 MODIFICATION NO.
SAFETY PAYS
PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI
U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA
ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE DEWATER WELLS
EAST EXTENSION SHEET 2 OF 3
JUNE 1980
71-07-16

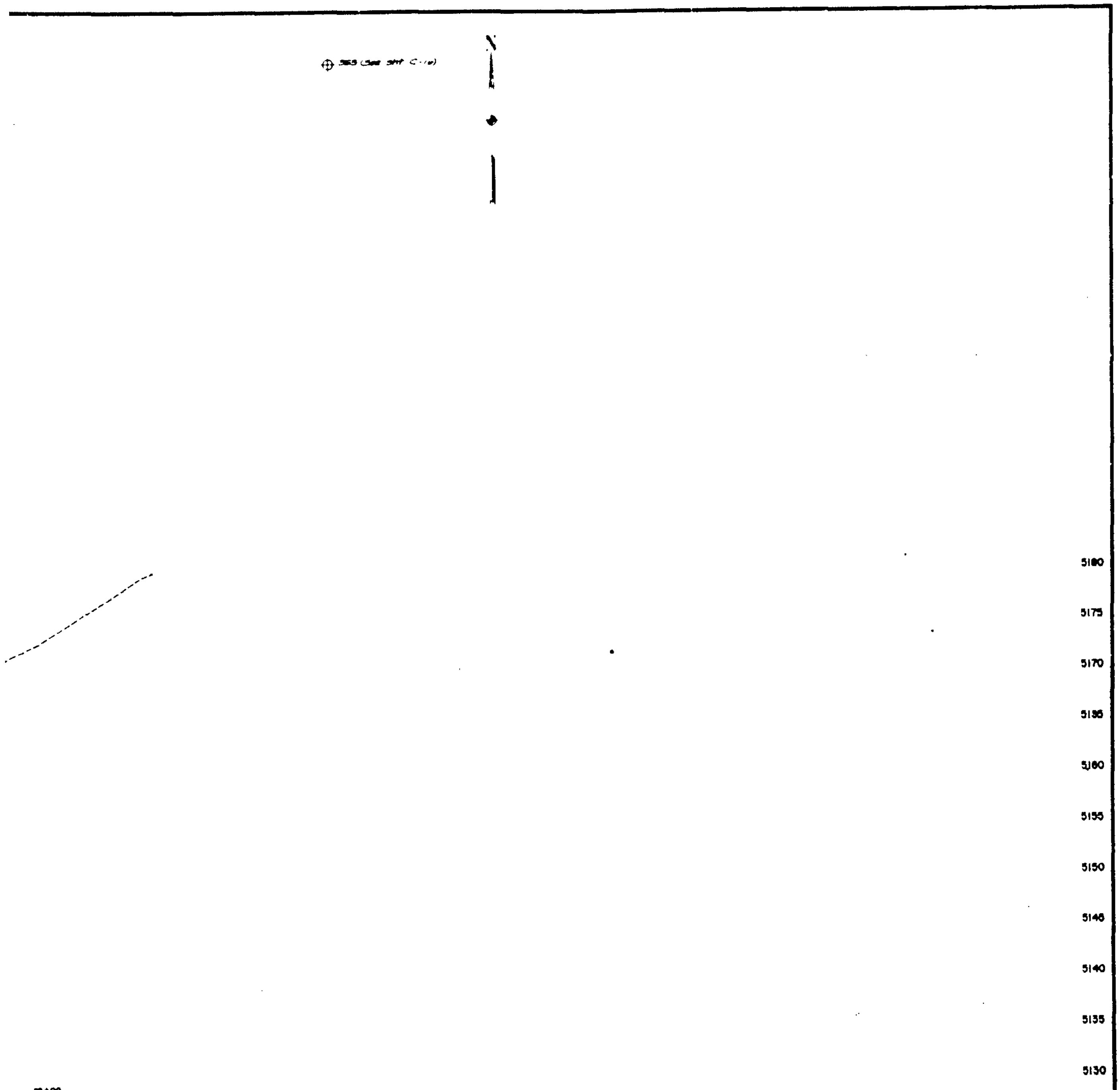


DEWATER WELLS PLAN
Scale 1" = 50.0'



NOTE:
WELL STATIONS BASED ON SLURRY TRENCH STATIONS.

PROFILE THROUGH ALLUVIAL DEWATER WELLS
Scale 1" = 50.0' Horiz.
1" = 3.0' Vert.



VIAL DEWATER WELLS

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

1" = 5'

1" = 50'

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 MODIFICATION NO.

SAFETY PAYS

DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT
OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

DESIGNED BY W.R.H
DRAWN BY J.N.S
CHECKED BY J.E.R
SUBMITTED BY
ARCHITECT - ENGINEER
RECOMMENDED
CHIEF DESIGN BRANCH

ROCKY MOUNTAIN ARSENAL, COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE DEWATER WELLS
EAST EXTENSION SHEET 3 OF 3

34

APPROVED:
CHIEF ENGINEERING DIVISION

DATE JUNE 1980

APPROVED:

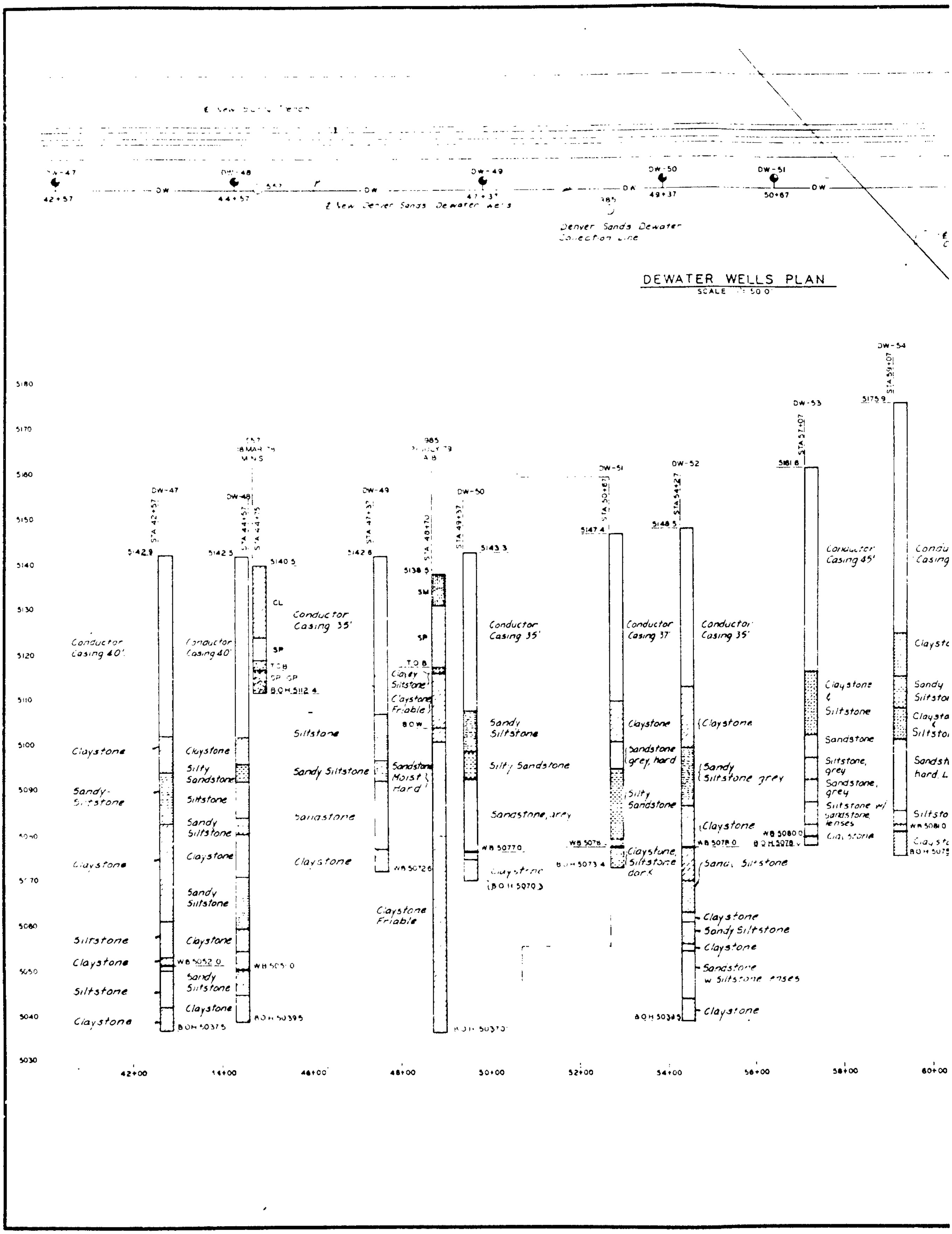
SCALE AS SHOWN

DWG. NO. DACA 45 80 R 0061

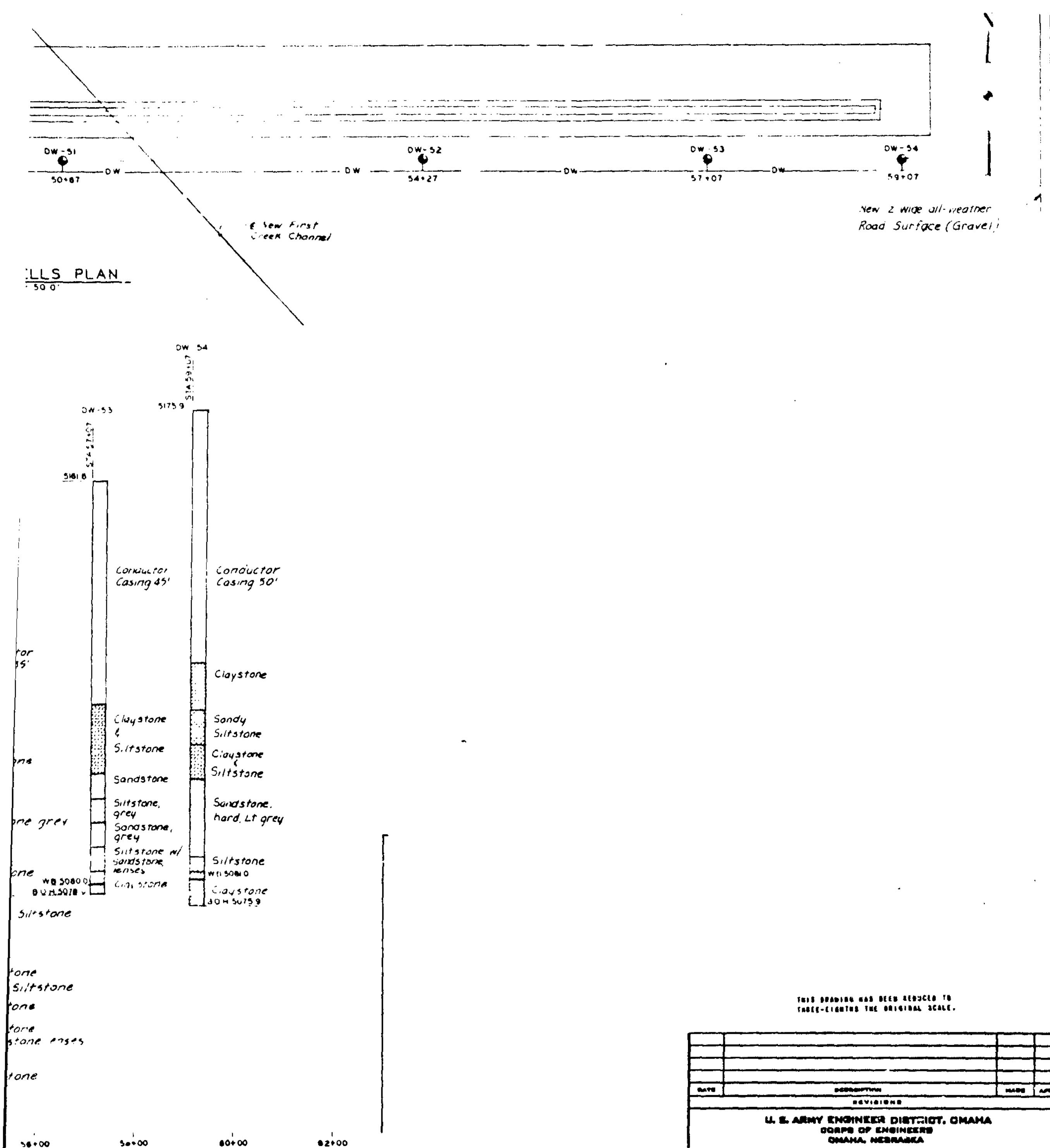
71-07-16

SHEET C-20

PLATE 34



DEWATER WELLS PLAN
Denver Sands Dewater Collection Line
DW-47
DW-48
DW-49
DW-50
DW-51
DW-52
DW-53
DW-54
Conductor Casing 40'
Conductor Casing 35'
Conductor Casing 37'
Conductor Casing 45'
Claystone
Sandy Siltstone
Siltstone
Silty Sandstone
Sandstone, grey
Sandstone grey, hard
Claystone Friable
Sandstone w Siltstone lenses



THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APP'D

REVISIONS

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

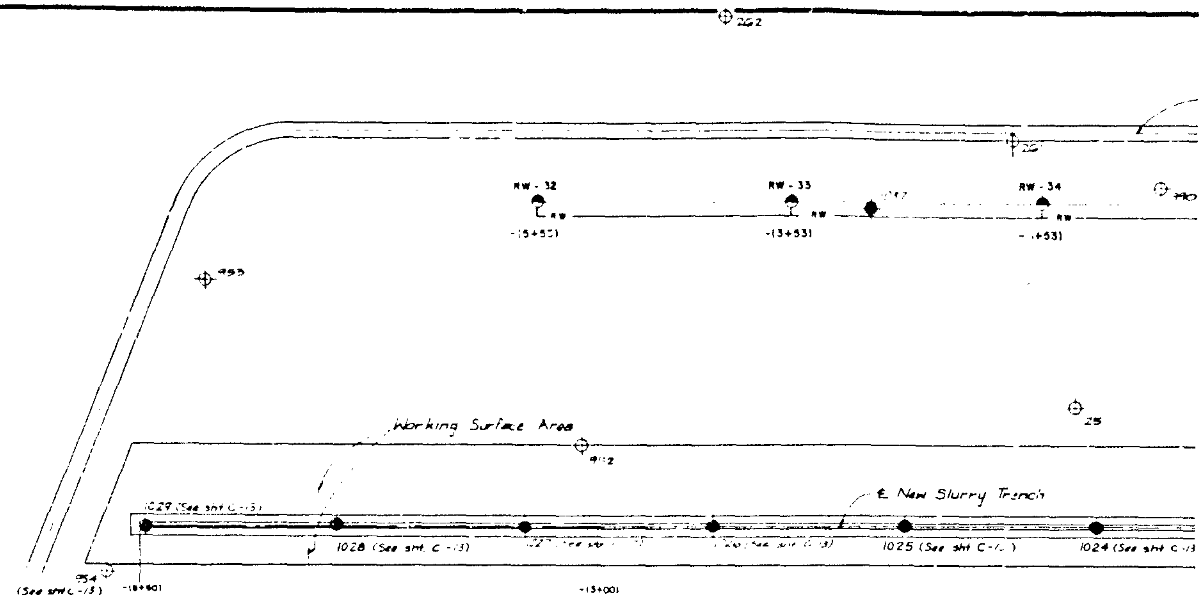
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
DENVER SANDS DEWATER WELLS
DW47 THROUGH DW54

SPEC. NO. DACA 45

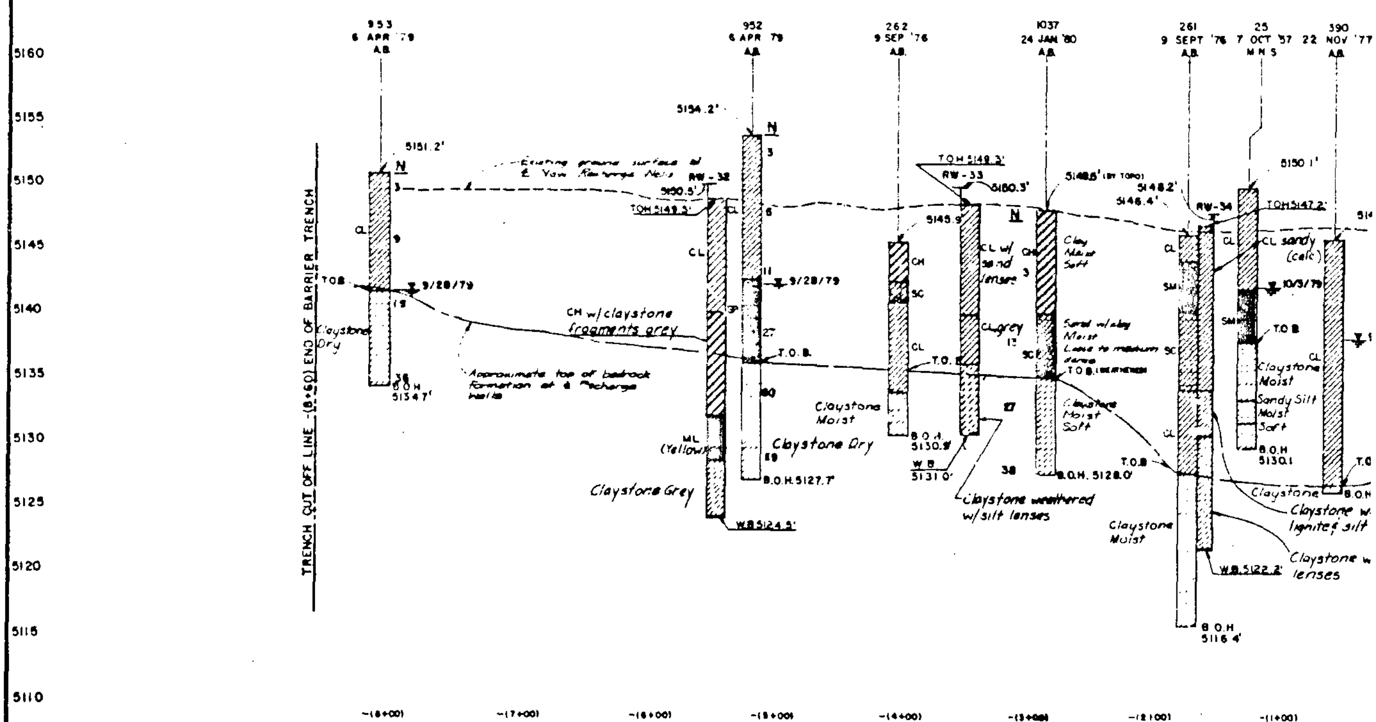
71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 MODIFICATION NO.

PLATE 36

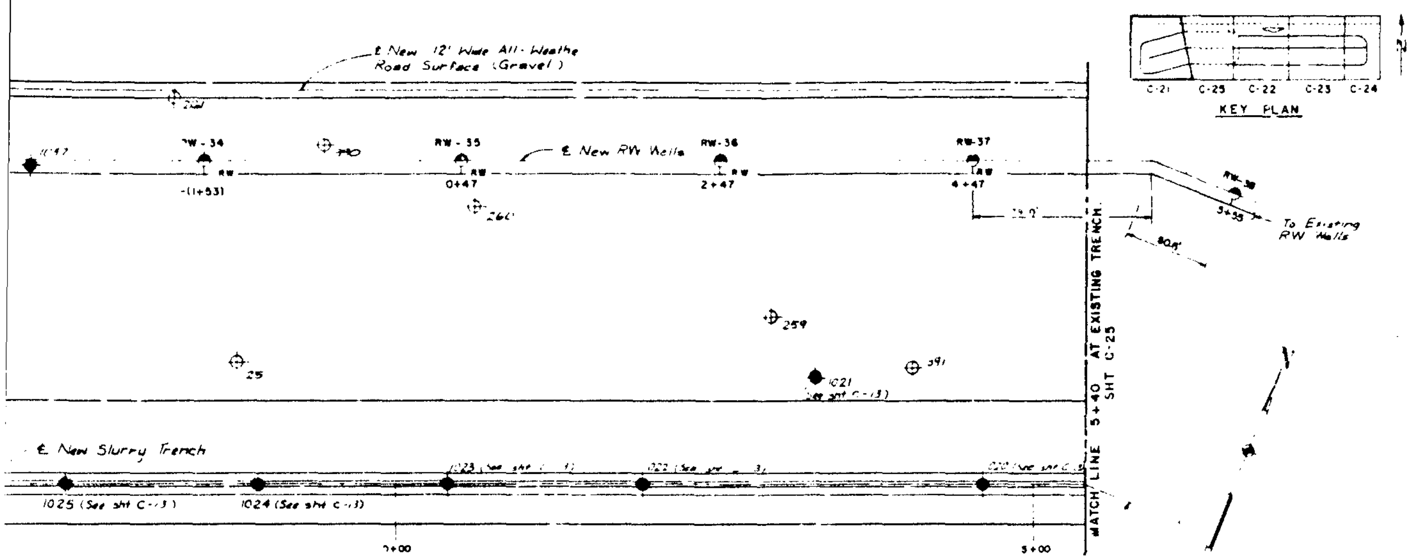


RECHARGE WELLS PLAN
Scale 1" = 50 0

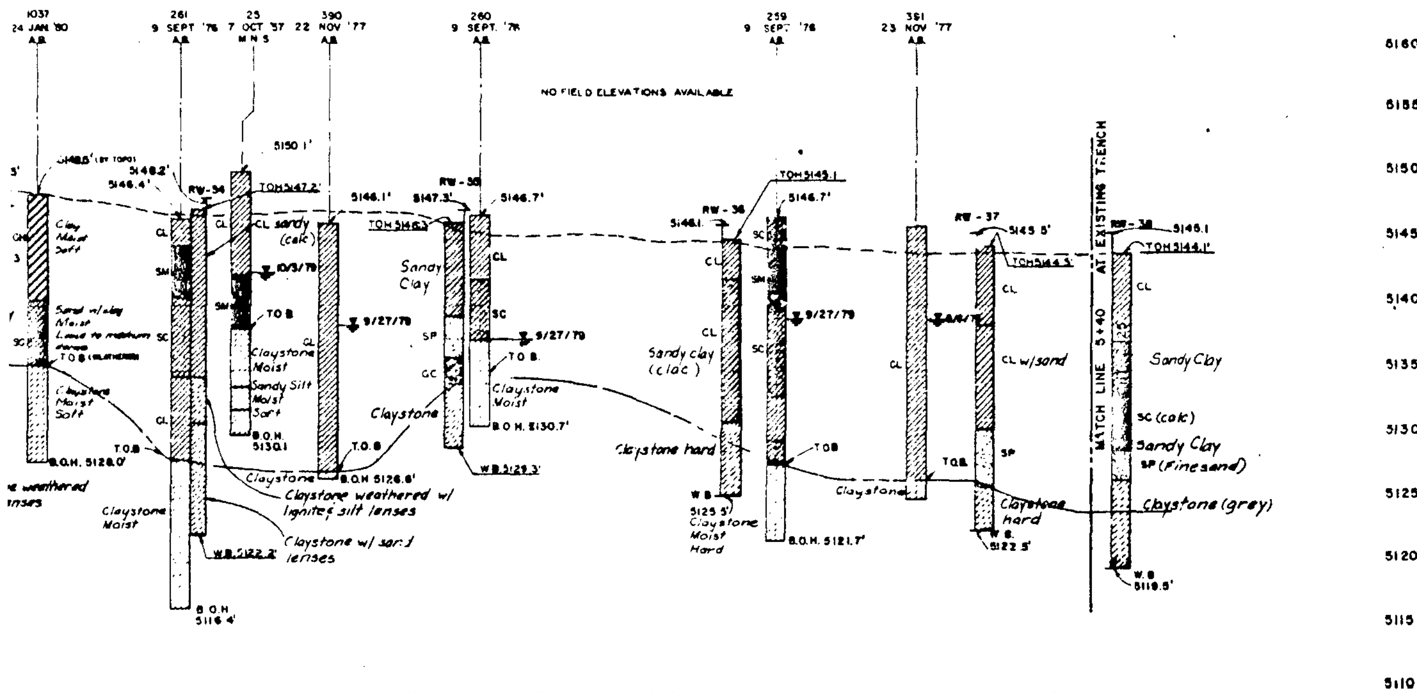


NOTE
WELL STATIONS BASED ON SLURRY TRENCH ℄ STATIONS.

PROFILE THROUGH RECHARGE
Scale 1" = 500' Horiz
1" = 50' Vert



RECHARGE WELLS PLAN
Scale 1"=50'0"



PROFILE THROUGH RECHARGE WELLS
Scale 1"=500' Horiz.
1"=50' Vert.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

1" = 5'
1" = 50'

DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT
OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

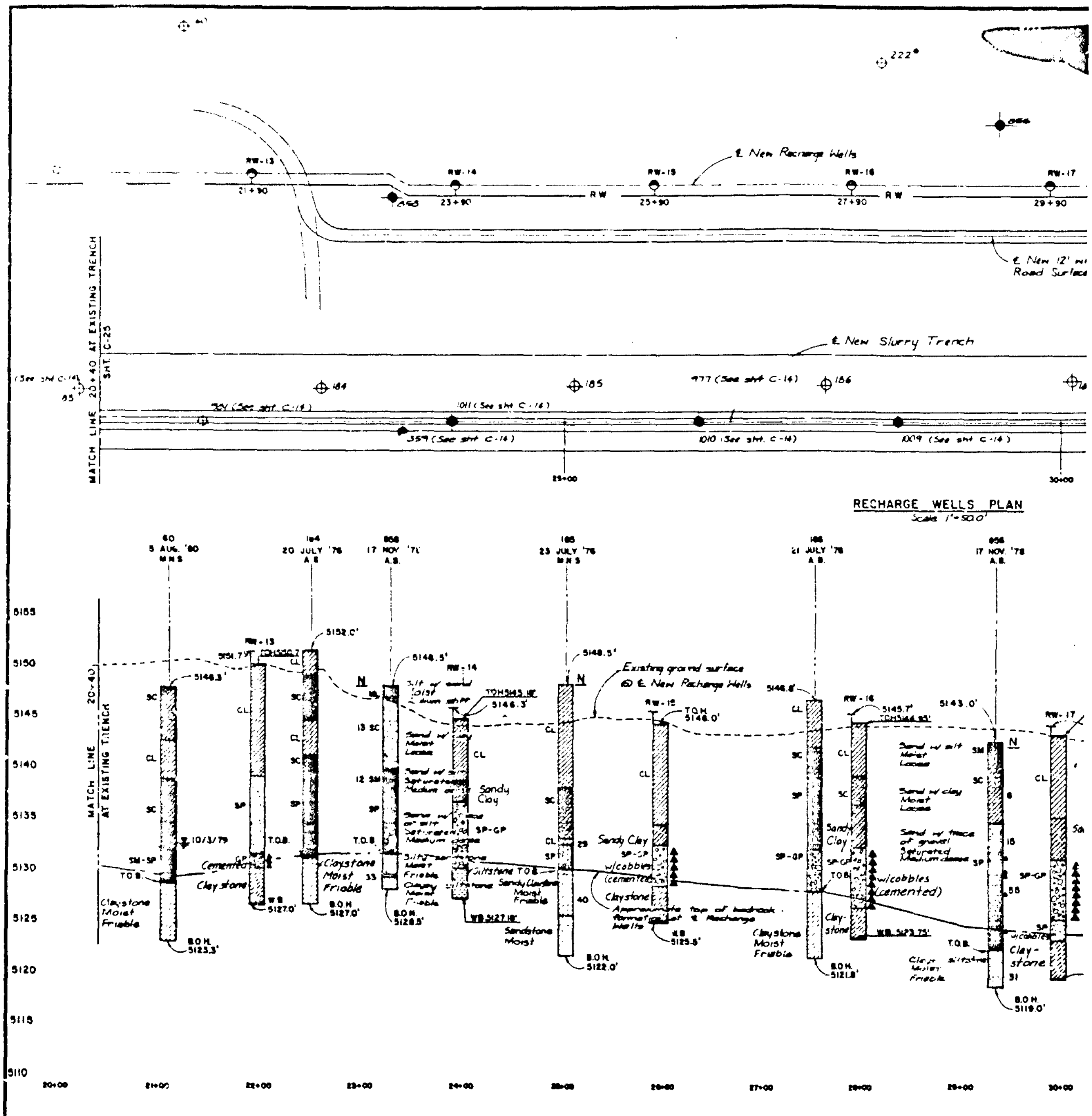
DESIGNED BY WRH
DRAWN BY MWH
CHECKED BY JER

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

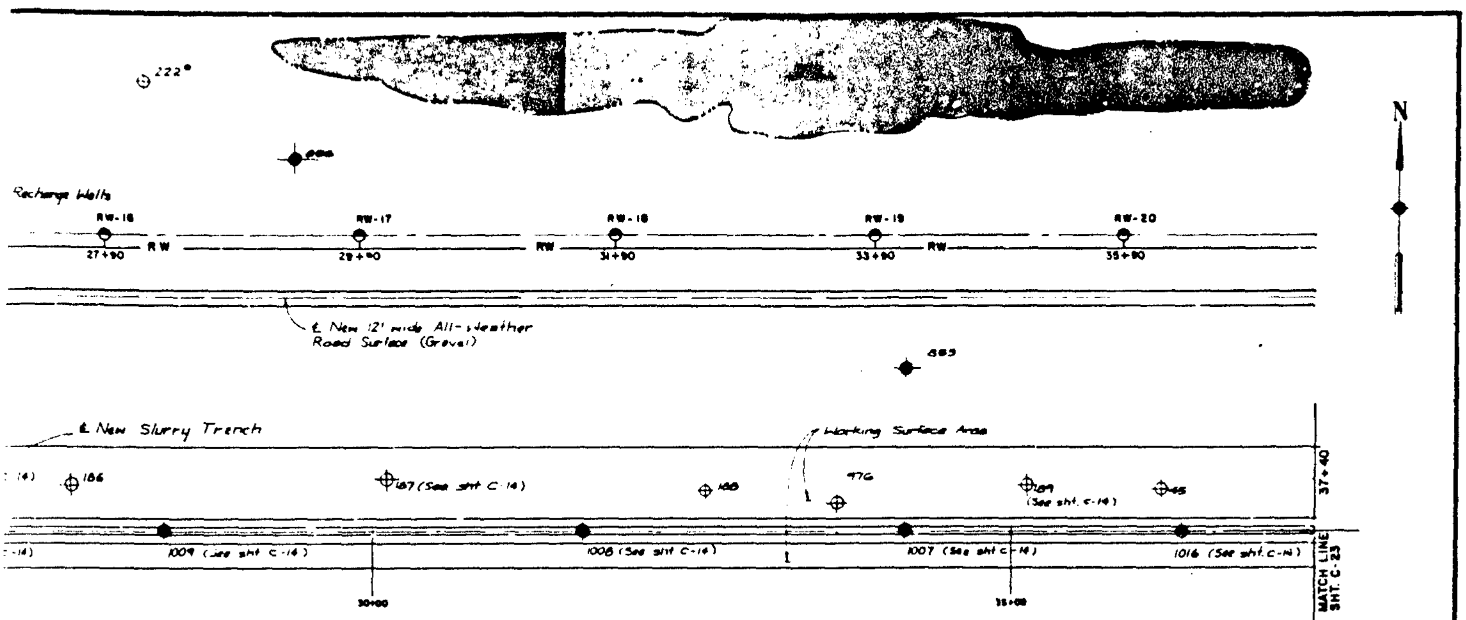
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE RECHARGE WELLS
WEST EXTENSION SHEET 1 OF 1

DATE: JUNE 1980
SPEC. NO. DACA 45-80-R-0161
SHEET C-21
71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45
MODIFICATION NO.

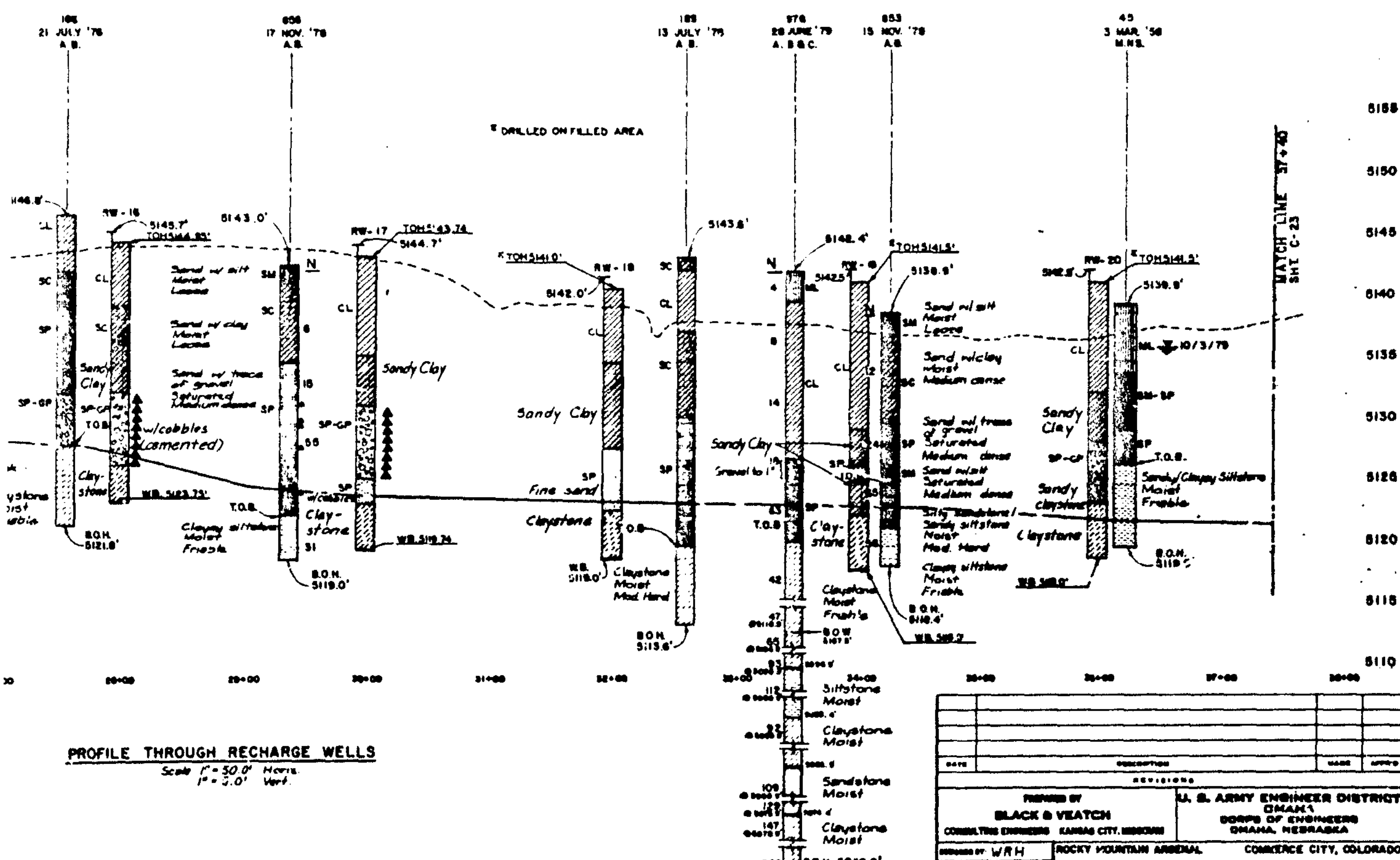


NOTE
WELL STATIONS BASED ON
SLURRY TRENCH ℄ STATIONS



RECHARGE WELLS PLAN

Scale 1"=50.0'



PROFILE THROUGH RECHARGE WELLS

Scale 1"=50.0' Horiz. 1"=5.0' Vert.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

1" = 5'

1" = 50'

THIS PLAN ACCOMPANIES CONTRACT NO.

SAFETY PAYS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY

NORTH BOUNDARY EXPANSION

PLAN AND PROFILE RECHARGE WELLS

EAST EXTENSION SHEET 1 OF 3

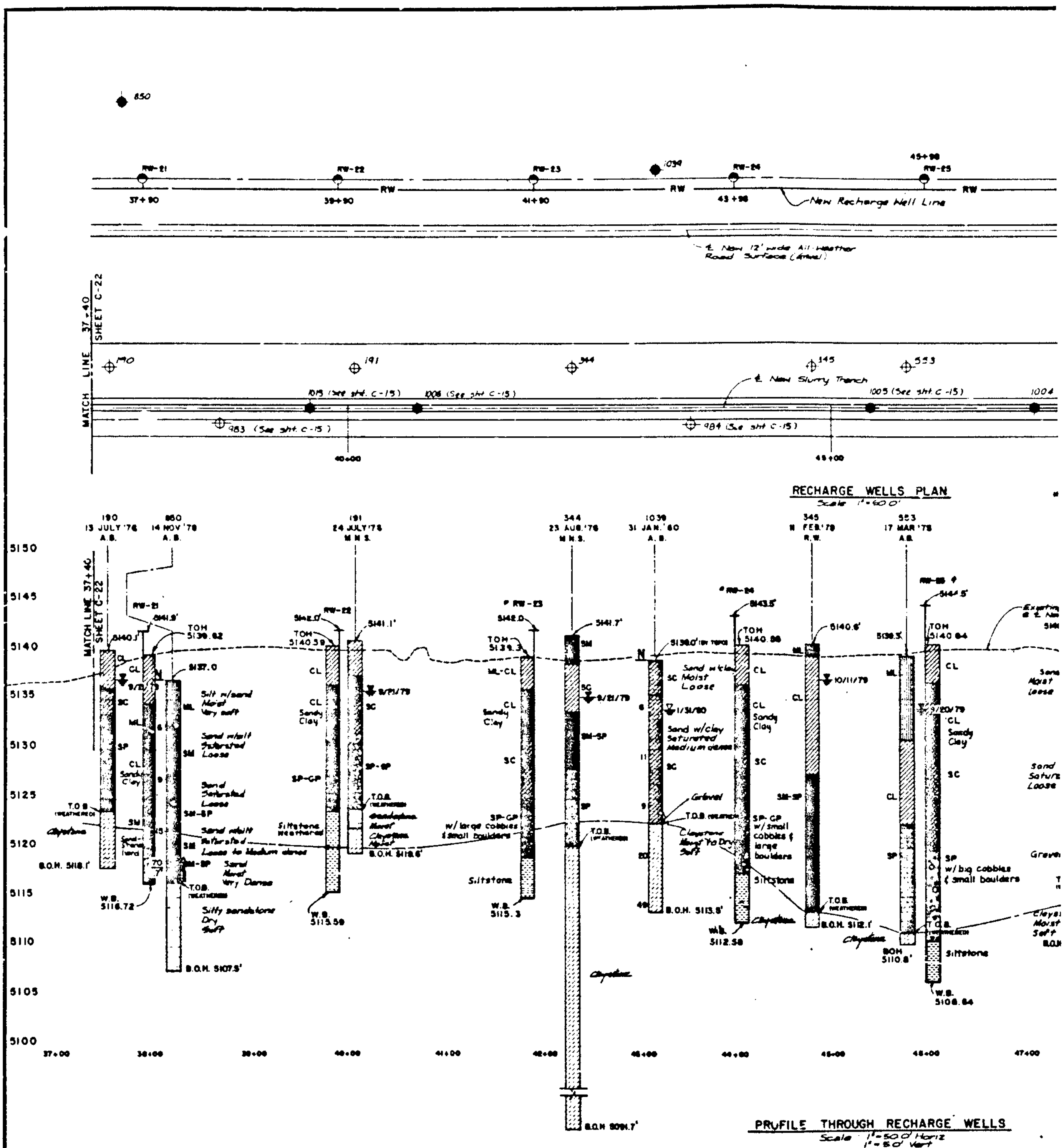
DESIGNED BY WRH

DRAWN BY

CHECKED BY JER

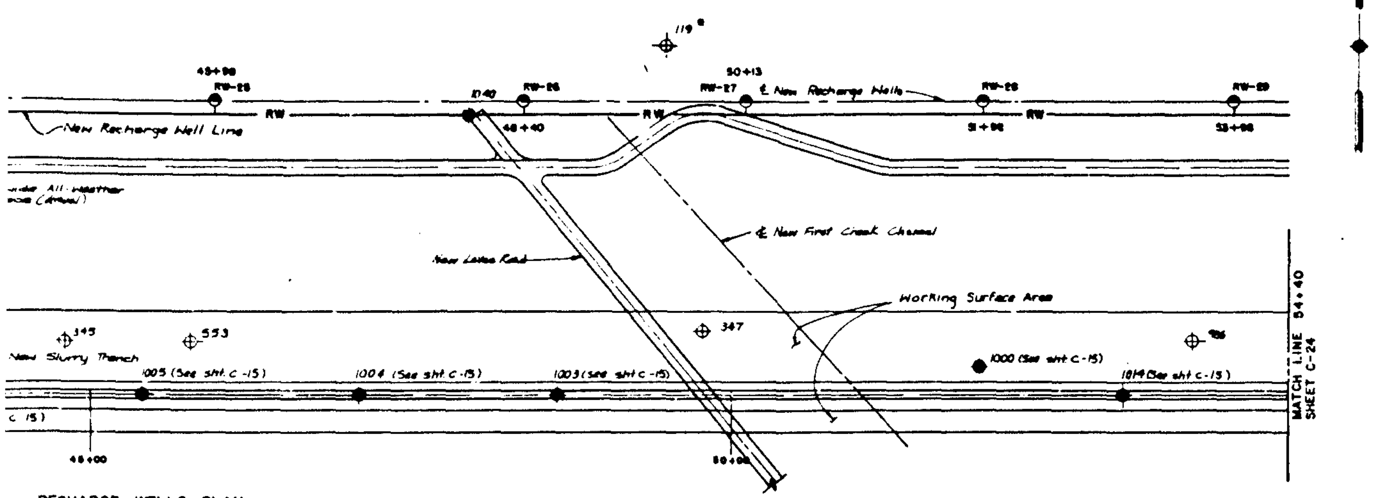
DATE JUNE 1980

71-07-16



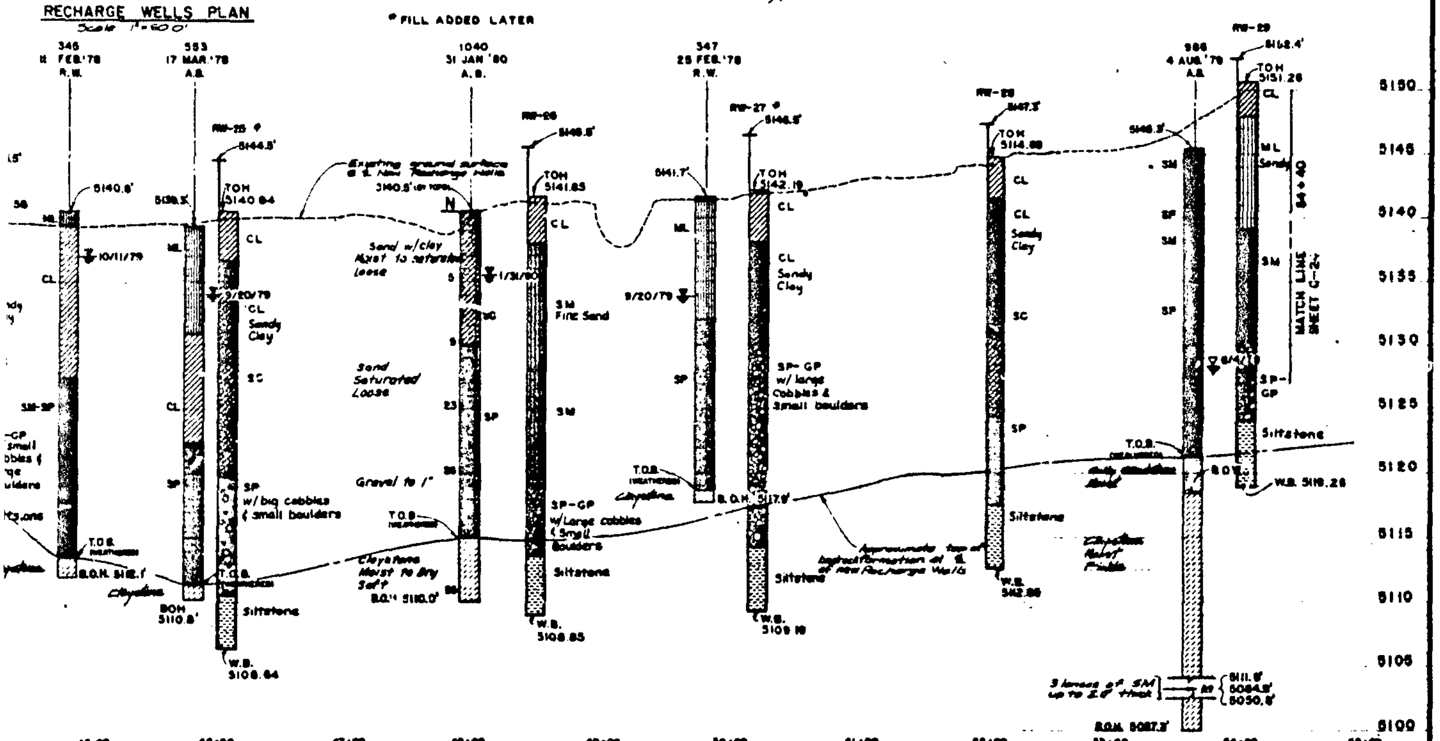
RECHARGE WELLS PLAN
Scale 1"=50'

PROFILE THROUGH RECHARGE WELLS
Scale 1"=50' Horiz
1"=5' Vert



RECHARGE WELLS PLAN
Scale 1"=50'

* FILL ADDED LATER



PROFILE THROUGH RECHARGE WELLS
Scale 1"=50' Horiz
1"=5.0' Vert.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

1" = 5'

1" = 50'

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 MODIFICATION NO.

SAFETY PAYS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

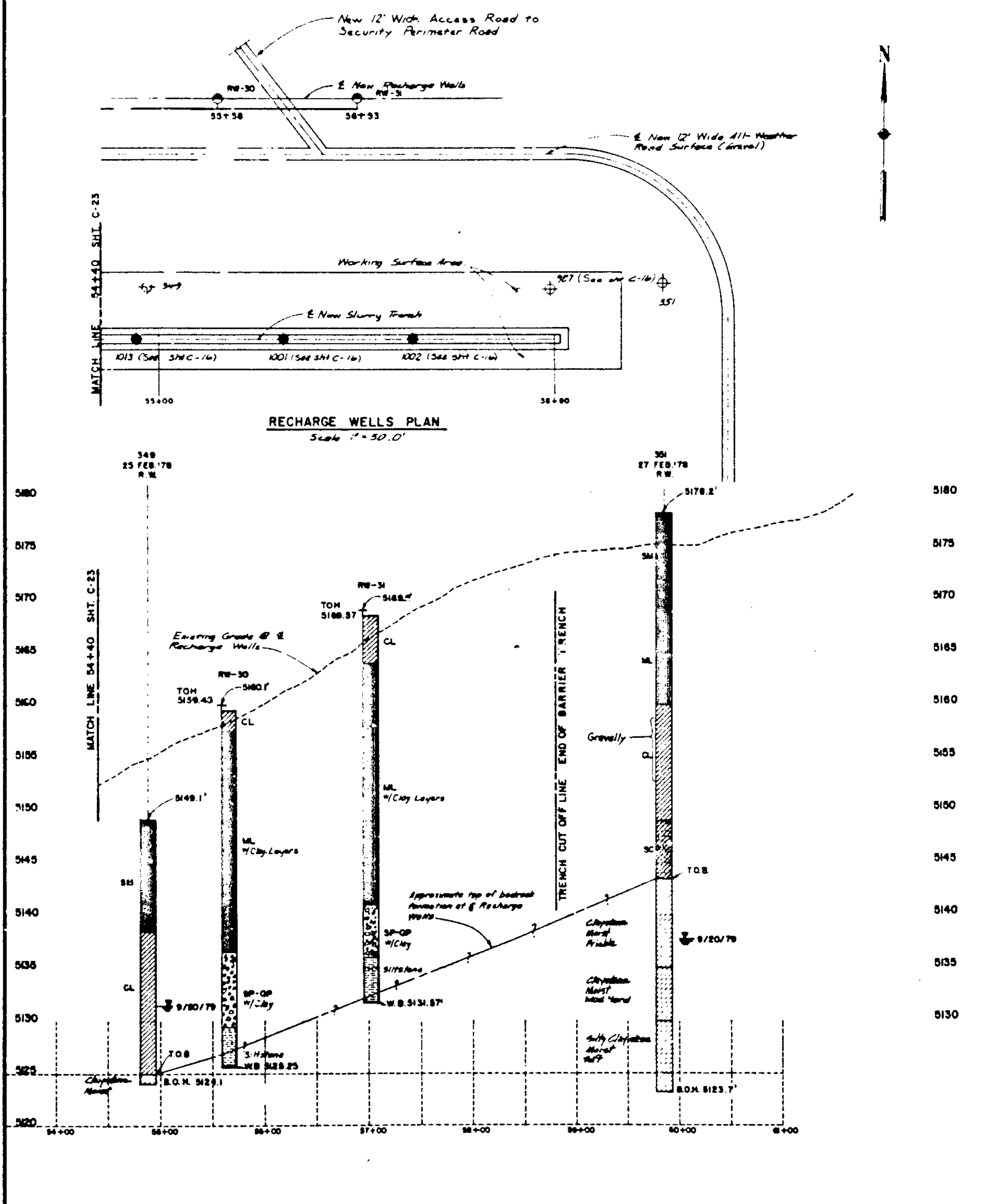
U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE RECHARGE WELLS
EAST EXTENSION SHEET 2 OF 3

JUNE 1980

C-23 71-07-16

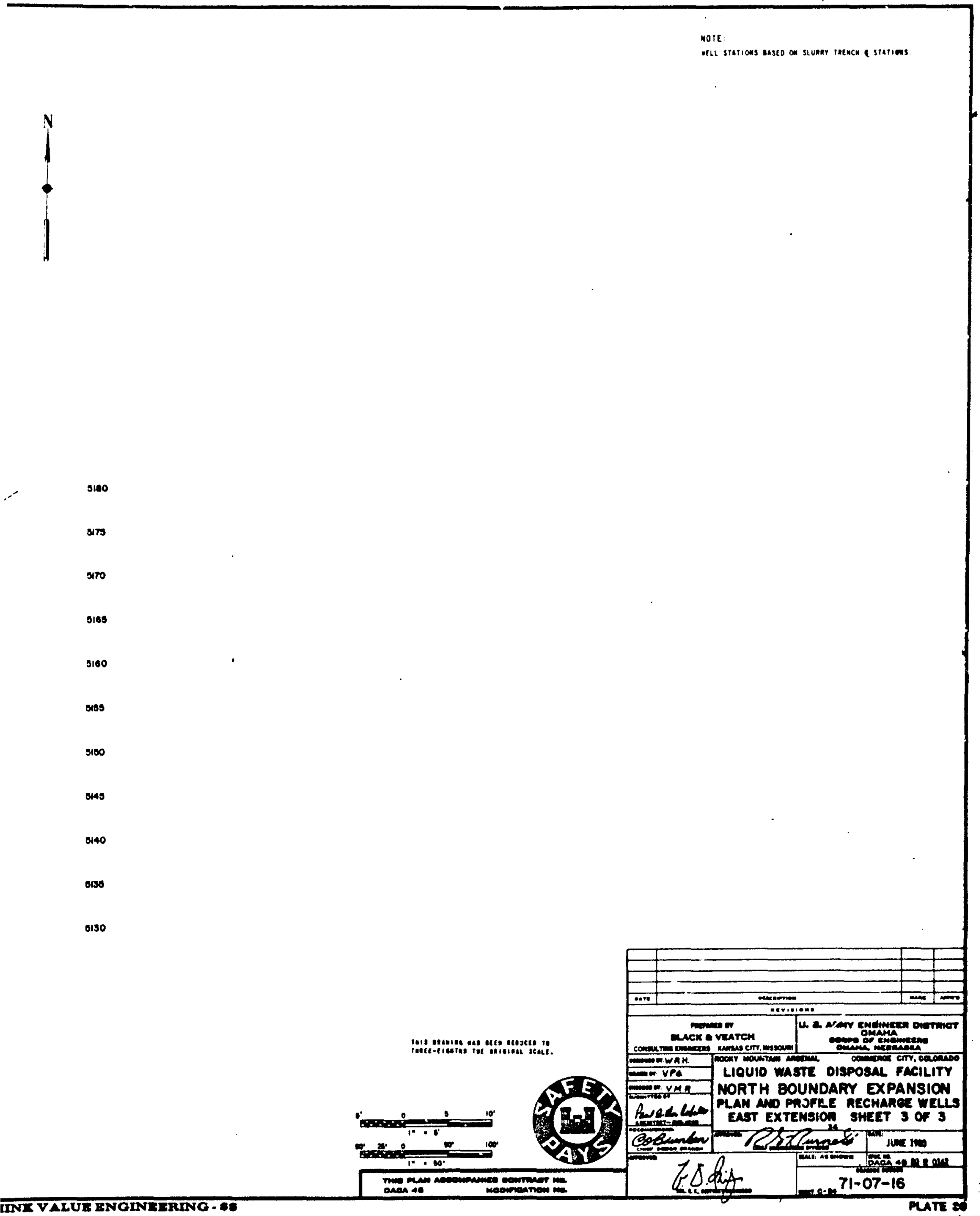


RECHARGE WELLS PLAN

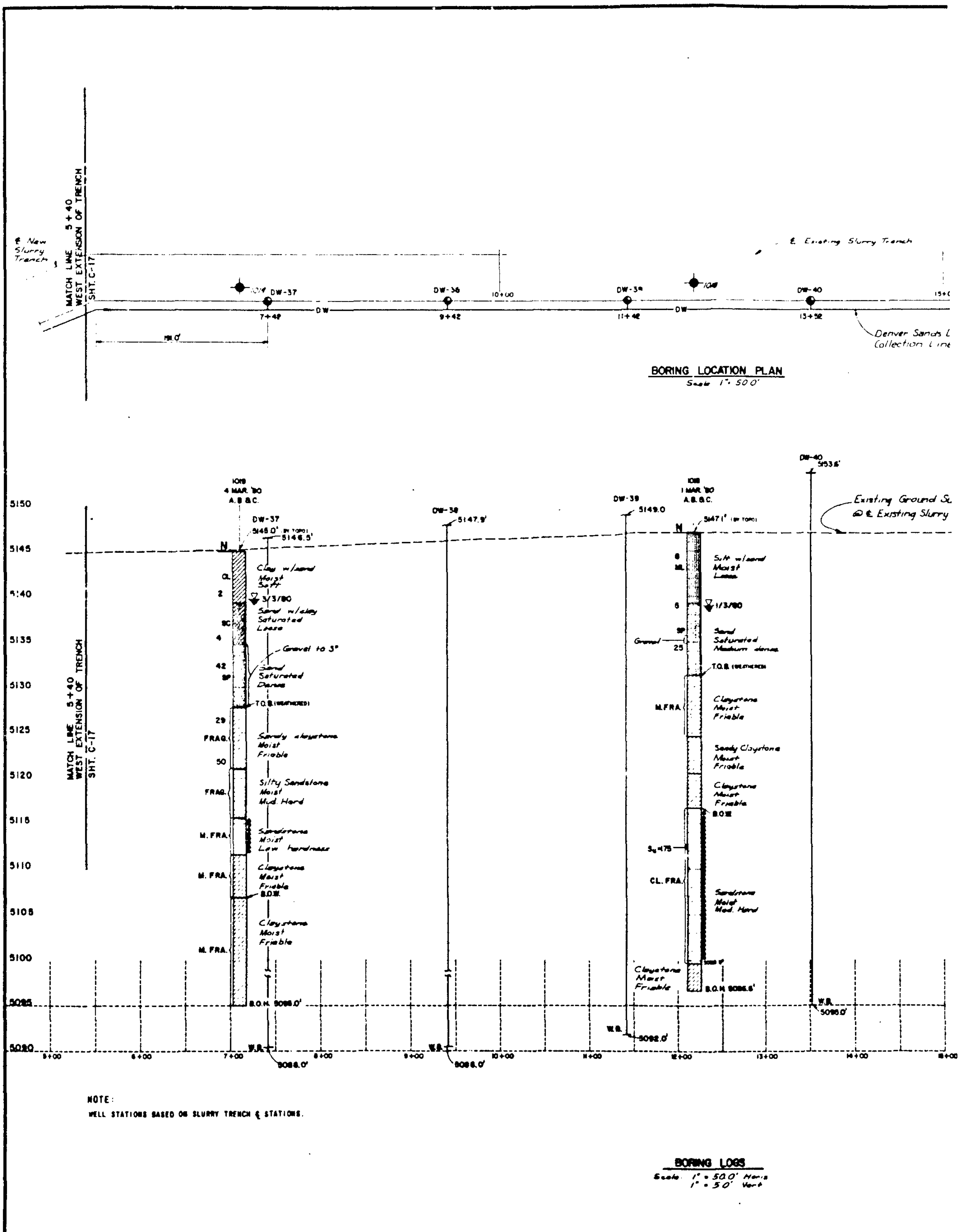
Scale 1" = 50.0'

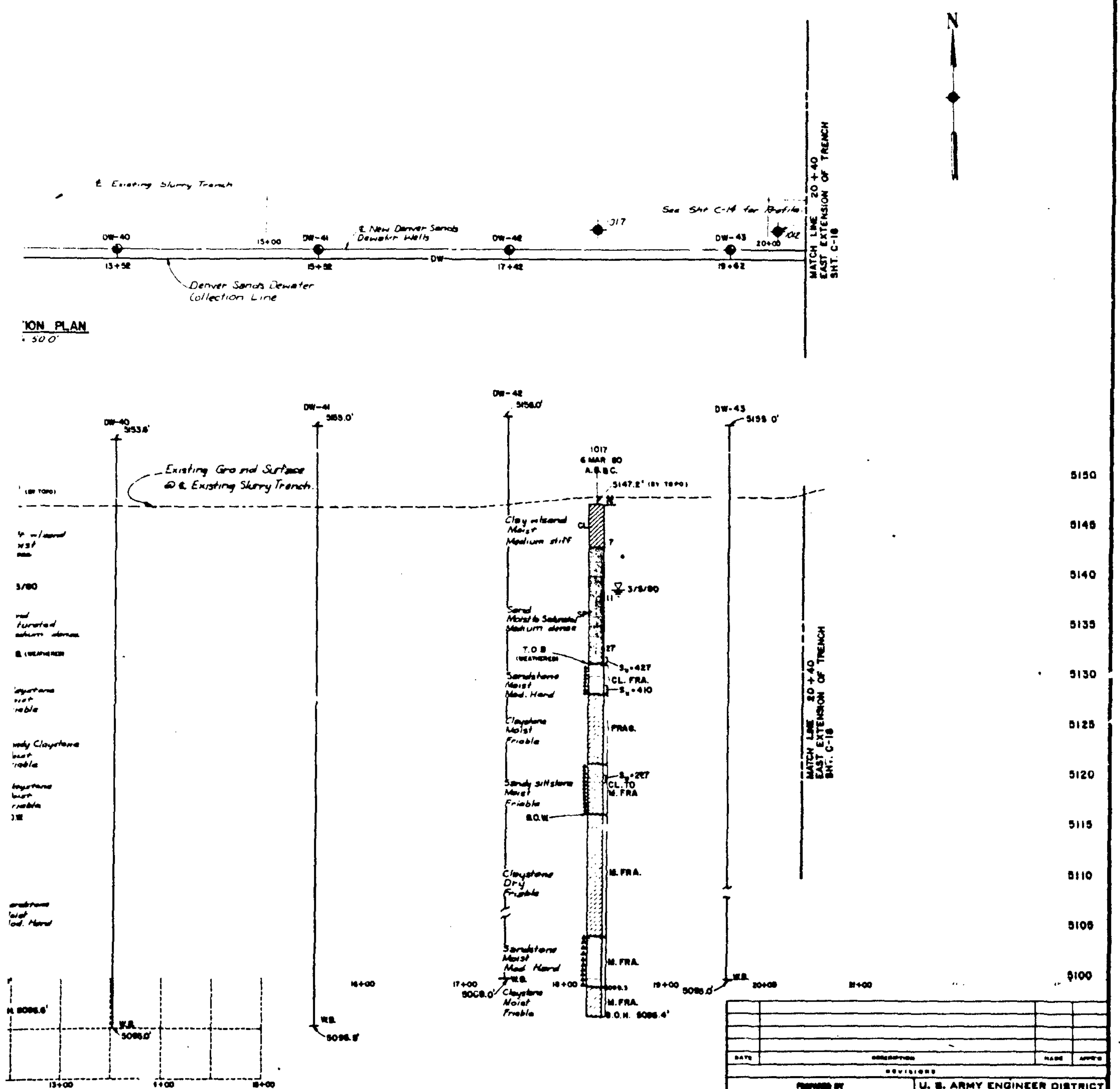
PROFILE THROUGH RECHARGE WELLS

Scale 1" = 50.0' Horiz.
1" = 5.0' Vert.



LINK VALUE ENGINEERING - 85


MATCH LINE 5+40
WEST EXTENSION OF TRENCH
SHT. C-17
DW-37
DW-38
DW-39
DW-40
7+42
9+42
11+42
13+52
10+00
Denver Sands
Collection Line
BORING LOCATION PLAN
Existing Ground Surface
@ ℄ Existing Slurry
Clay w/sand
Moist
Soft
Sand w/clay
Saturated
Loose
Gravel to 3"
Sand
Saturated
Dense
Sandy claystone
Moist
Friable
Silty Sandstone
Moist
Mod. Hard
Sandstone
Moist
Low hardness
Claystone
Moist
Friable
Silt w/sand
Moist
Loose
Sand
Saturated
Medium dense
Sandy Claystone
Sandstone
Moist
Mod. Hard
5150
5145
5140
5135
5130
5125
5120
5115
5110
5105
5100
5095
5090
NOTE:
WELL STATIONS BASED ON SLURRY TRENCH ℄ STATIONS.
BORING LOGS
Scale 1" = 50.0' Horiz
1" = 5.0' Vert



THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

1" = 5'

1" = 50'

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 MODIFICATION NO.

DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

DESIGNED BY W.R.H.
DRAWN BY V.P.G.
CHECKED BY J.E.R.

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

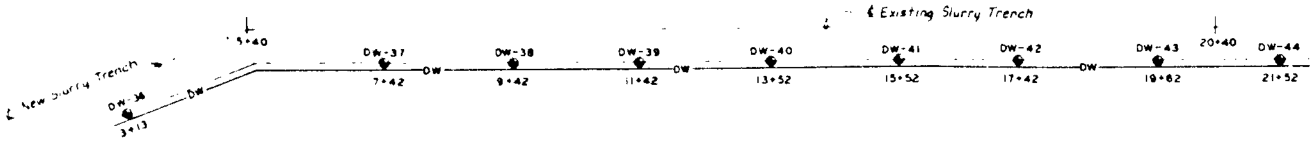
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PLAN AND PROFILE DEWATER WELLS VICINITY OF EXISTING BARRIER

34

DATE: JUNE 1980

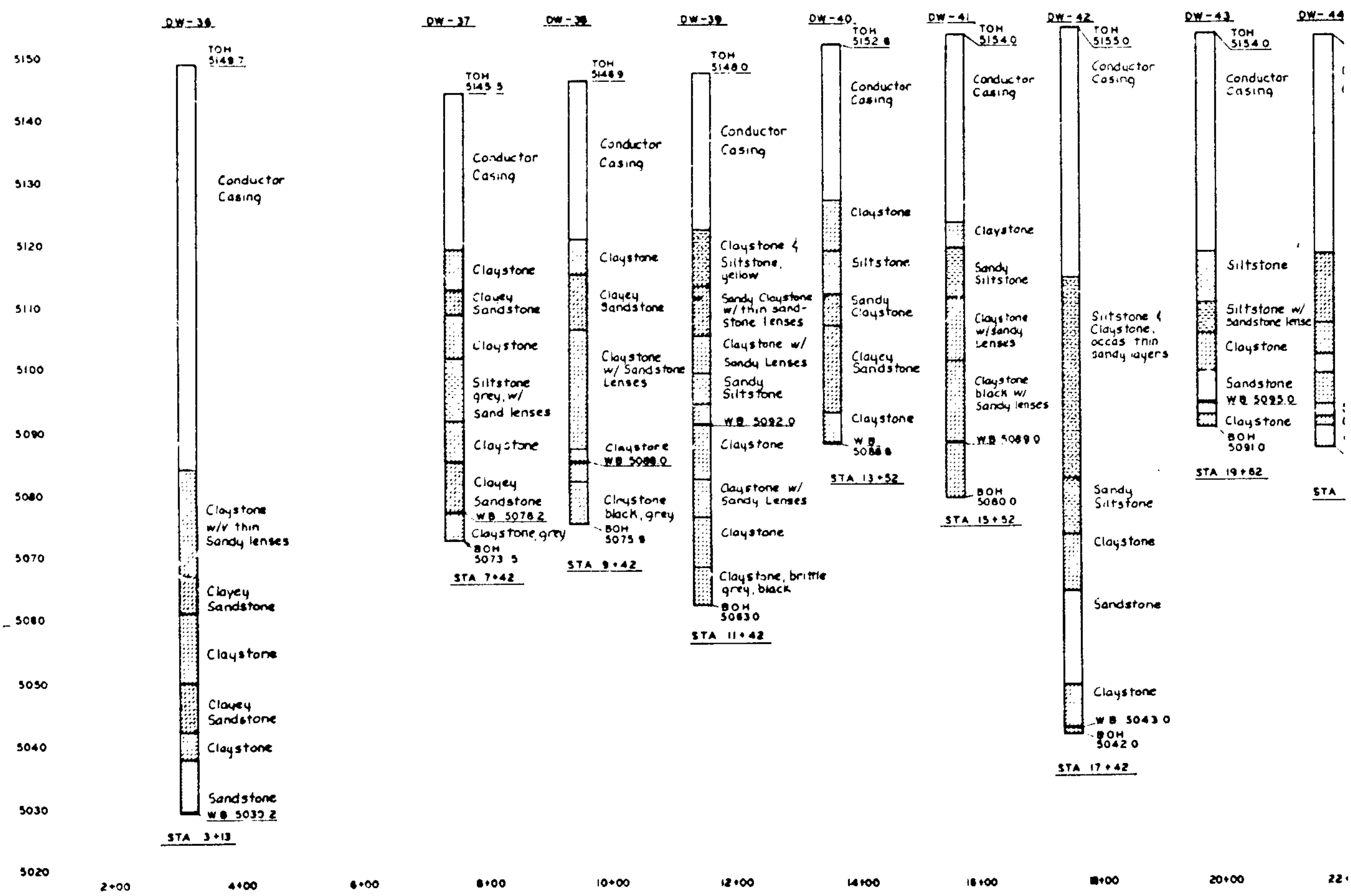
DACA 45

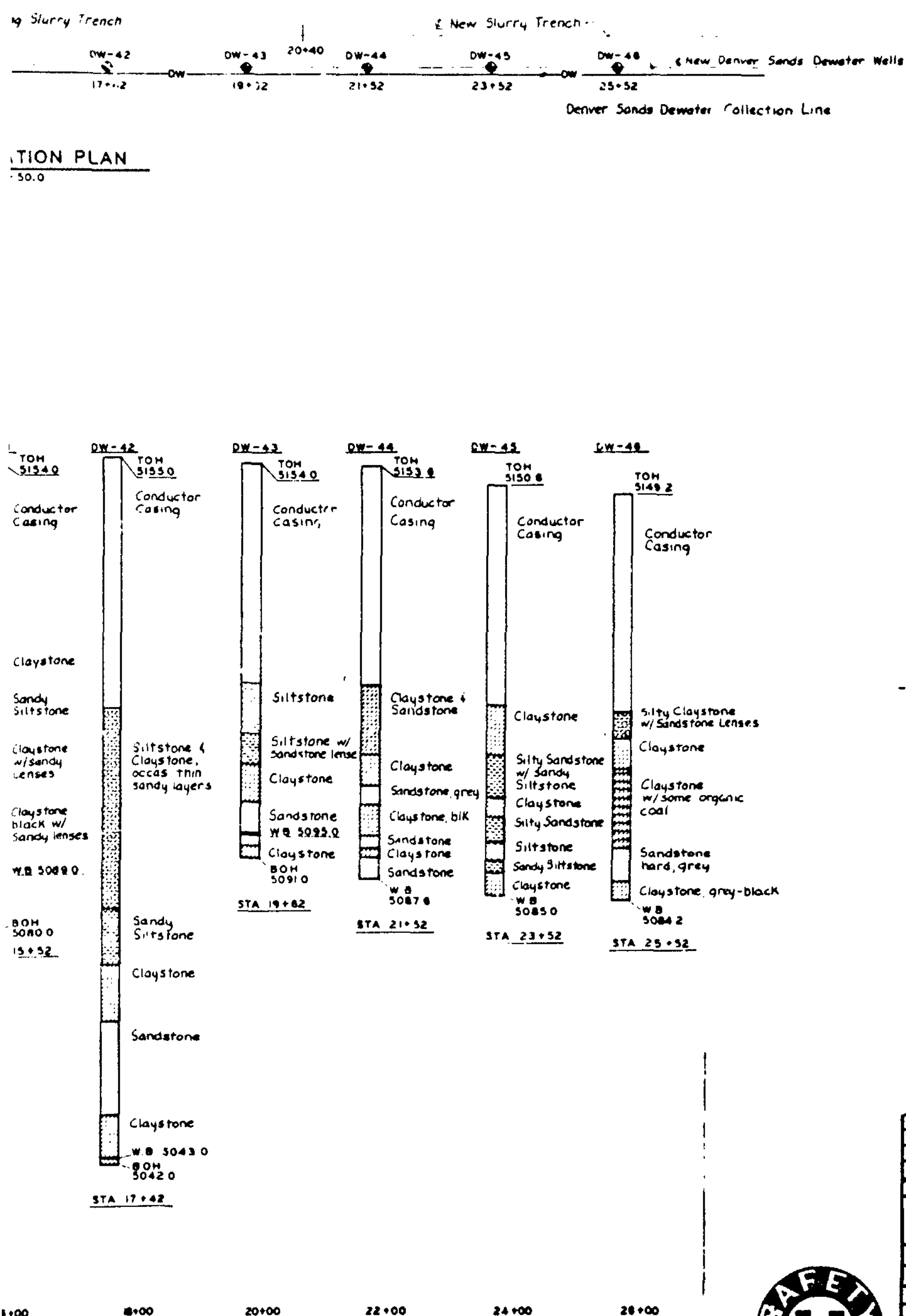
71-07-16



BORING LOCATION PLAN

SCALE 1"=50.0





THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

U. S. ARMY ENGINEER DISTRICT
OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

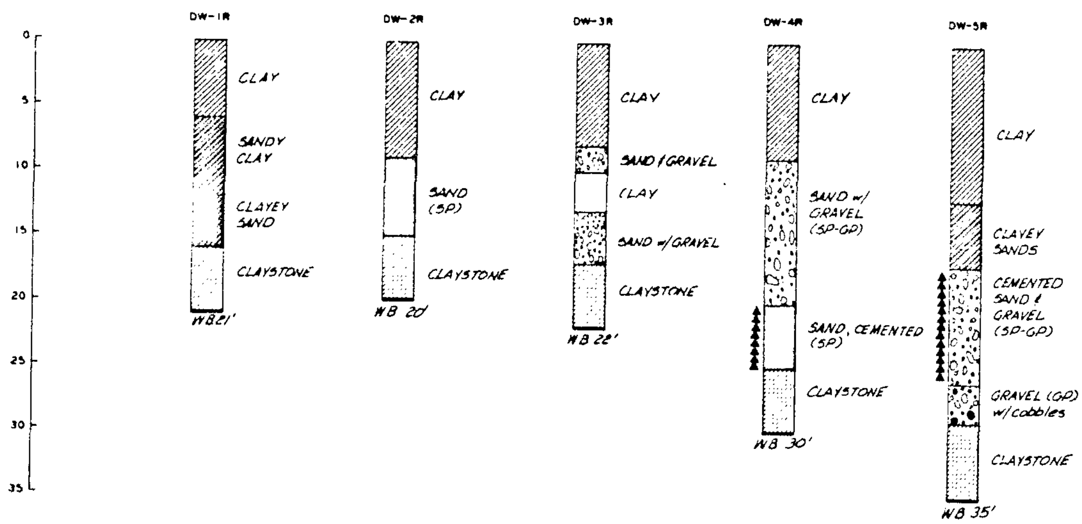
ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

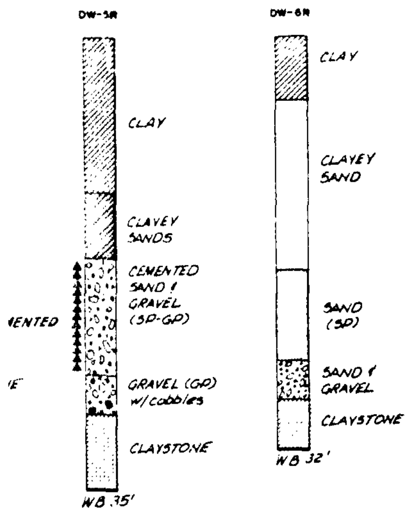
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
DENVER SAND DEWATER WELLS
DW 36 THROUGH DW 46

THIS PLAN ACCOMPANIES CONTRACT NO.
MODIFICATION NO.

71-07-16

PLATE 41


DW-1R
DW-2R
DW-3R
DW-4R
DW-5R
0
5
10
15
20
25
30
35
CLAY
SANDY CLAY
CLAYEY SAND
CLAYSTONE
WB 21'
CLAY
SAND (SP)
CLAYSTONE
WB 20'
CLAY
SAND / GRAVEL
CLAY
SAND w/GRAVEL
CLAYSTONE
WB 22'
CLAY
SAND w/ GRAVEL (SP-GP)
SAND, CEMENTED (SP)
CLAYSTONE
WB 30'
CLAY
CLAYEY SANDS
CEMENTED SAND & GRAVEL (SP-GP)
GRAVEL (GP) w/cobbles
CLAYSTONE
WB 35'



THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

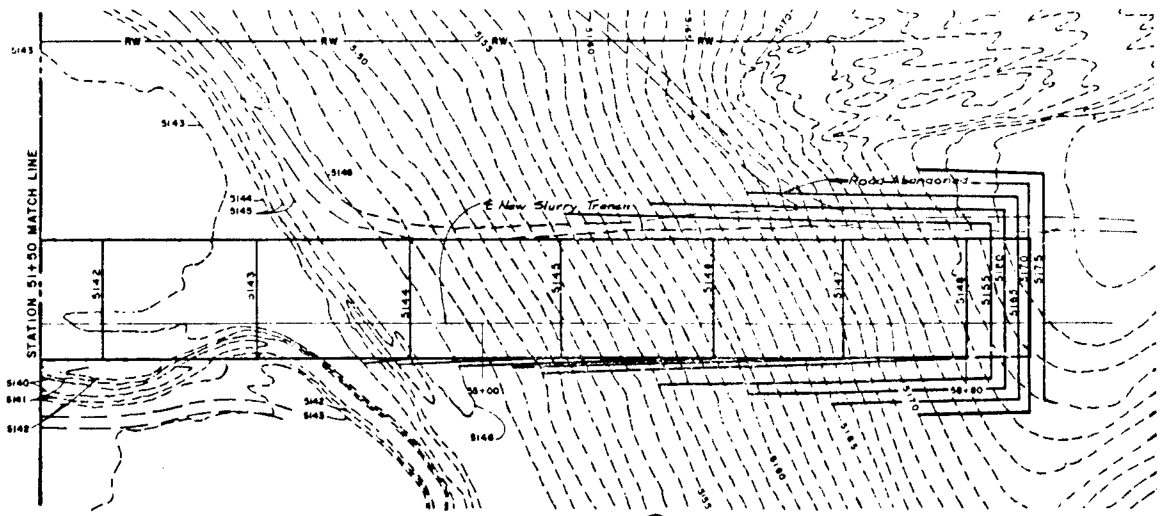
ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PILOT SYSTEM DEWATER WELLS
REPLACEMET WELL BORING LOGS

SCALE: AS SHOWN

THIS PLAN ACCOMPANIES CONTRACT NO.
MODIFICATION NO.

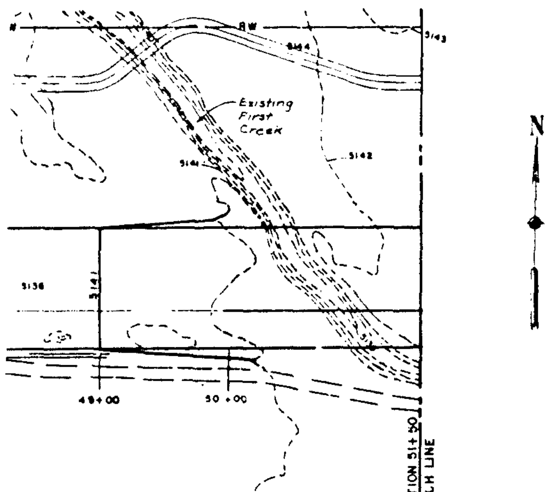
71-07-16



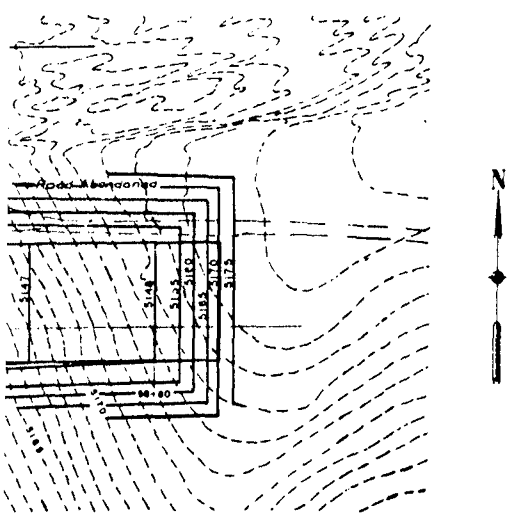
STATION 51 + 50 THRU 58+80
Scale 1" = 50'

NOTE

SLURRY RETURN DITCH AND DRAINAGE DITCH NOT SHOWN FOR CLARITY. REFER TO SECTION 1 (C-27 | C-37) FOR ADDITIONAL INFORMATION.



STA. 49+00 THRU 51+50



50 THRU 58+80

1" = 50'

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

A1	1-29-81	Changed Contours Surface over Slurry Trench		
1	8-13-80	REVISED IN ACCORDANCE WITH AM. NO. 0001		C.O.B
	DATE	DESCRIPTION	MADE	APPD

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

DESIGNED BY: YMB/DAR
DRAWN BY: MWM
CHECKED BY: JER

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
WORKING SURFACE CONTOURS (RECOMMENDED)-STA. 49+00 TO 59+50
SHEET 1

DATE: JUNE 1980

SCALE: AS SHOWN

SPEC. NO. DACA45-80-B-0068

71-07-16

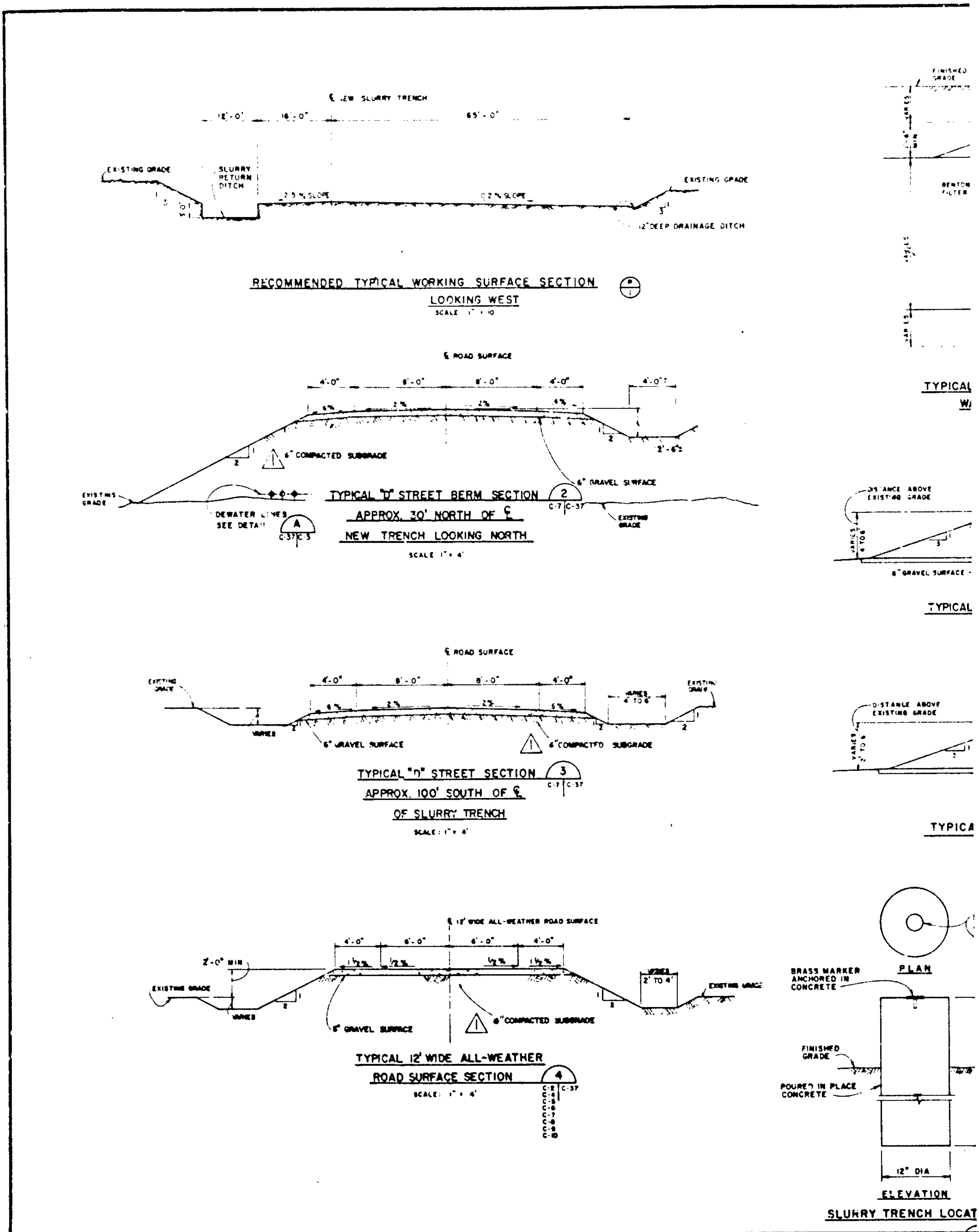
SHEET C-27

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 81 C0054 MODIFICATION NO. P00001

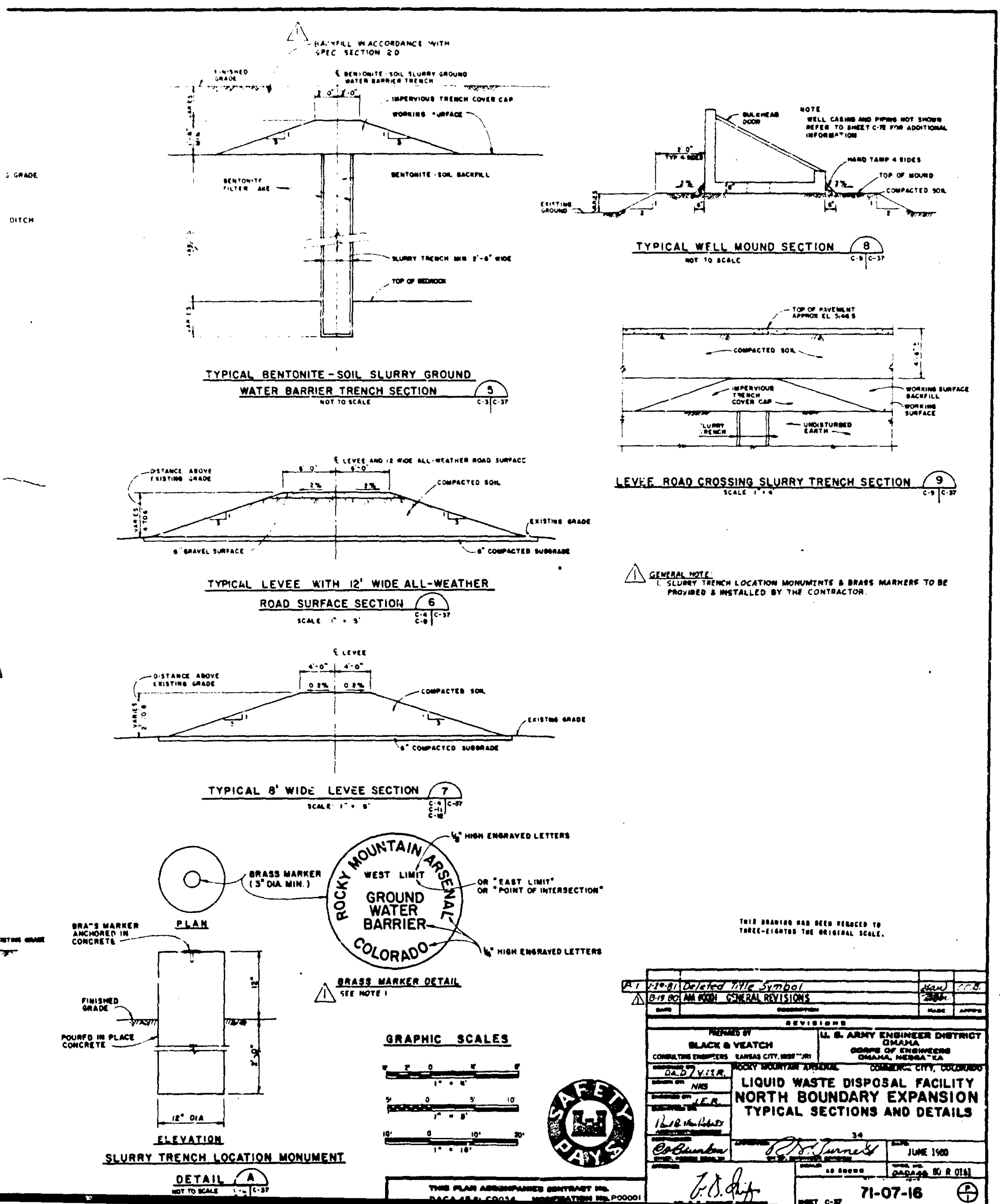
SAFETY PAYS

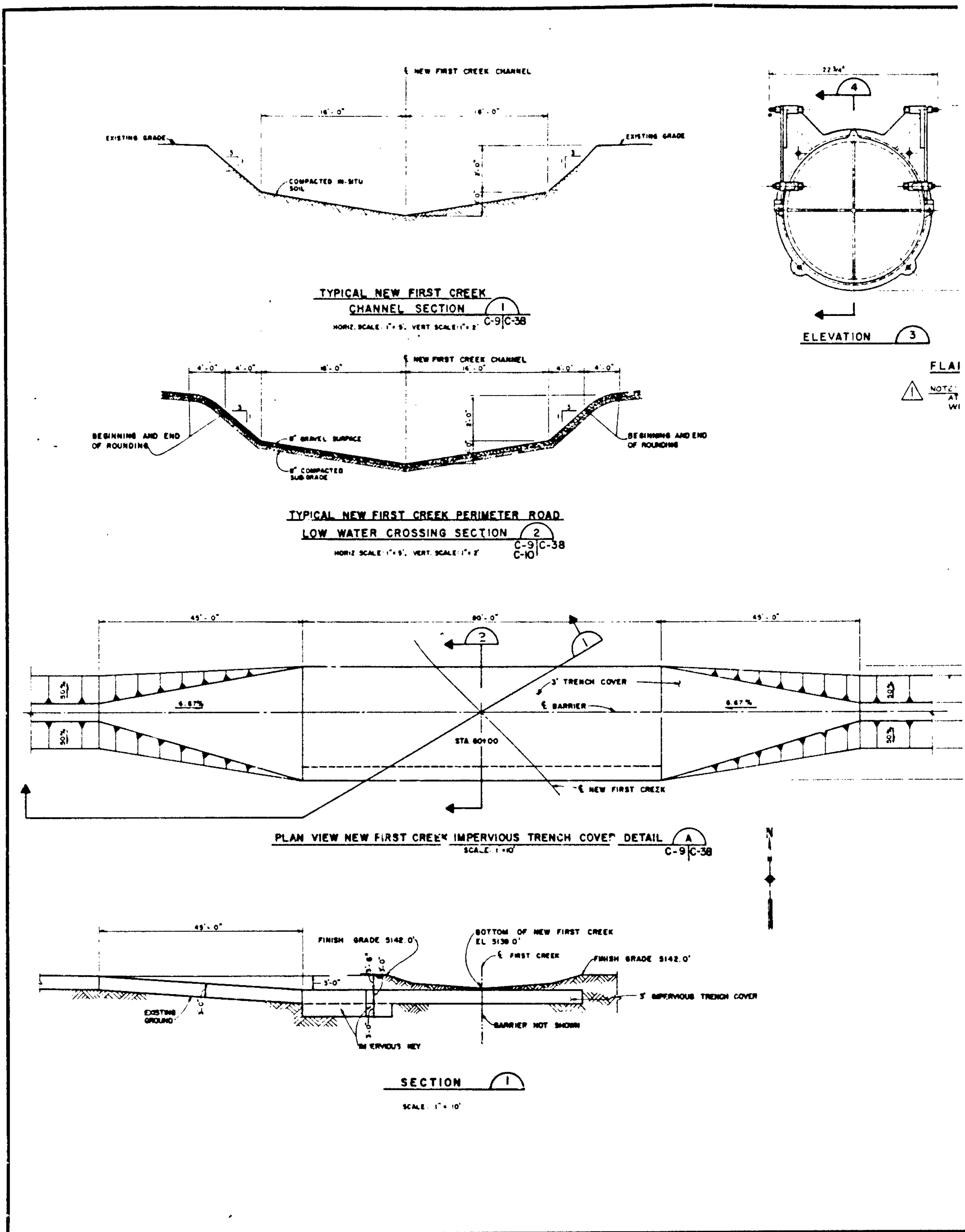
$$ – THINK VALUE ENGINEERING – $$

PLATE 46

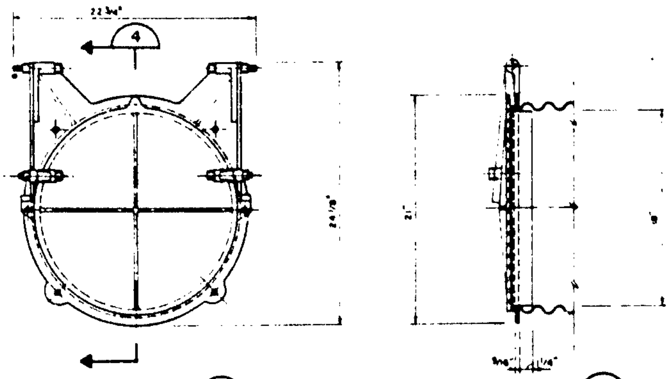


℄ NEW SLURRY TRENCH
12'-0"
16'-0"
65'-0"
EXISTING GRADE
SLURRY RETURN DITCH
2.5% SLOPE
2% SLOPE
12" DEEP DRAINAGE DITCH
RECOMMENDED TYPICAL WORKING SURFACE SECTION
LOOKING WEST
℄ ROAD SURFACE
4'-0"
8'-0"
8'-0"
4'-0"
6" COMPACTED SUBGRADE
6" GRAVEL SURFACE
EXISTING GRADE
DEWATER LINES SEE DETAIL
TYPICAL "D" STREET BERM SECTION
APPROX. 30' NORTH OF ℄
NEW TRENCH LOOKING NORTH
℄ ROAD SURFACE
EXISTING GRADE
VARIES
VARIES 4' TO 6'
6" GRAVEL SURFACE
6" COMPACTED SUBGRADE
TYPICAL "D" STREET SECTION
APPROX. 100' SOUTH OF ℄
OF SLURRY TRENCH
℄ 12' WIDE ALL-WEATHER ROAD SURFACE
4'-0"
6'-0"
6'-0"
4'-0"
2'-0" MIN
EXISTING GRADE
VARIES
VARIES 2' TO 4'
6" GRAVEL SURFACE
6" COMPACTED SUBGRADE
TYPICAL 12' WIDE ALL-WEATHER
ROAD SURFACE SECTION
FINISHED GRADE
TYPICAL
TYPICAL
TYPICA
DISTANCE ABOVE EXISTING GRADE
6" GRAVEL SURFACE
BRASS MARKER ANCHORED IN CONCRETE
PLAN
FINISHED GRADE
POURED IN PLACE CONCRETE
12" DIA
ELEVATION
SLURRY TRENCH LOCAT


BACKFILL IN ACCORDANCE WITH SPEC SECTION 2D
FINISHED GRADE
℄ BENTONITE-SOIL SLURRY GROUND WATER BARRIER TRENCH
IMPERVIOUS TRENCH COVER CAP
WORKING SURFACE
BENTONITE-SOIL BACKFILL
BENTONITE FILTER CAKE
SLURRY TRENCH MIN 2'-6" WIDE
TOP OF BEDROCK
TYPICAL BENTONITE-SOIL SLURRY GROUND WATER BARRIER TRENCH SECTION
NOT TO SCALE
BULKHEAD DOOR
NOTE
WELL CASING AND PIPING NOT SHOWN REFER TO SHEET C-7E FOR ADDITIONAL INFORMATION
HAND TAMP 4 SIDES
TOP OF MOUND
COMPACTED SOIL
EXISTING GROUND
TYPICAL WELL MOUND SECTION
NOT TO SCALE
TOP OF PAVEMENT APPROX EL 5146.5
COMPACTED SOIL
IMPERVIOUS TRENCH COVER CAP
WORKING SURFACE BACKFILL
WORKING SURFACE
SLURRY TRENCH
UNDISTURBED EARTH
LEVEE ROAD CROSSING SLURRY TRENCH SECTION
DISTANCE ABOVE EXISTING GRADE
℄ LEVEE AND 12 WIDE ALL-WEATHER ROAD SURFACE
COMPACTED SOIL
EXISTING GRADE
6" GRAVEL SURFACE
6" COMPACTED SUBGRADE
TYPICAL LEVEE WITH 12' WIDE ALL-WEATHER ROAD SURFACE SECTION
SCALE 1" = 5'
GENERAL NOTE:
1. SLURRY TRENCH LOCATION MONUMENTS & BRASS MARKERS TO BE PROVIDED & INSTALLED BY THE CONTRACTOR.
℄ LEVEE
4'-0" 4'-0"
0.2% 0.2%
COMPACTED SOIL
EXISTING GRADE
6" COMPACTED SUBGRADE
TYPICAL 8' WIDE LEVEE SECTION
1/8" HIGH ENGRAVED LETTERS
BRASS MARKER (3" DIA. MIN.)
ROCKY MOUNTAIN ARSENAL
WEST LIMIT
GROUND WATER BARRIER
COLORADO
OR "EAST LIMIT" OR "POINT OF INTERSECTION"
PLAN
BRASS MARKER ANCHORED IN CONCRETE
FINISHED GRADE
POURED IN PLACE CONCRETE
12" DIA
ELEVATION
SLURRY TRENCH LOCATION MONUMENT
DETAIL A
NOT TO SCALE
BRASS MARKER DETAIL
SEE NOTE 1
GRAPHIC SCALES
THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.
SAFETY PAYS
Deleted Title Symbol
GENERAL REVISIONS
REVISIONS
PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI
U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
TYPICAL SECTIONS AND DETAILS
JUNE 1980
AS SHOWN
71-07-16
SHEET C-37
THIS PLAN ACCOMPANIES CONTRACT NO.
MODIFICATION No. P00001



℄ NEW FIRST CREEK CHANNEL
16' - 0"
16' - 0"
EXISTING GRADE
EXISTING GRADE
COMPACTED IN-SITU SOIL
2'-0"
TYPICAL NEW FIRST CREEK
CHANNEL SECTION
1
C-9 C-38
HORIZ. SCALE: 1"= 5', VERT. SCALE: 1"= 2'
22 3/4"
4
ELEVATION
3
FLA
NOTE
℄ NEW FIRST CREEK CHANNEL
4'-0"
4'-0"
16'-0"
16'-0"
4'-0"
4'-0"
2'-0"
BEGINNING AND END OF ROUNDING
BEGINNING AND END OF ROUNDING
6" GRAVEL SURFACE
6" COMPACTED SUB GRADE
TYPICAL NEW FIRST CREEK PERIMETER ROAD
LOW WATER CROSSING SECTION
2
C-9 C-38
C-10
HORIZ. SCALE: 1"= 5', VERT. SCALE: 1"= 2'
45'-0"
80'-0"
45'-0"
2
1
3' TRENCH COVER
℄ BARRIER
6.67%
6.67%
30%
30%
30%
30%
STA. 60+00
℄ NEW FIRST CREEK
PLAN VIEW NEW FIRST CREEK IMPERVIOUS TRENCH COVER DETAIL
A
SCALE: 1"=10'
C-9 C-38
N
45'-0"
FINISH GRADE 5142.0'
BOTTOM OF NEW FIRST CREEK EL. 5139.0'
℄ FIRST CREEK
FINISH GRADE 5142.0'
3'-0"
3' IMPERVIOUS TRENCH COVER
EXISTING GROUND
IMPERVIOUS KEY
BARRIER NOT SHOWN
SECTION
1
SCALE: 1"= 10'

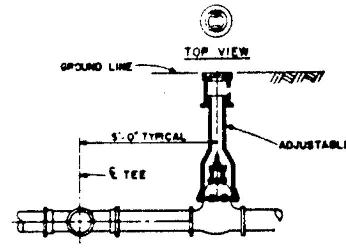


ELEVATION (3)

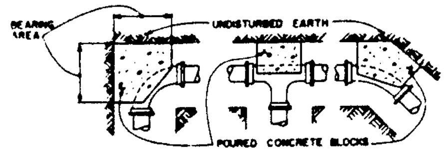
SECTION (4)

FLAP GATE DETAIL (B / C-9 | C-38)
SCALE 1" = 6"

NOTE:
ATTACHMENT TO CULVERT IN ACCORDANCE WITH MFR'S INSTRUCTIONS

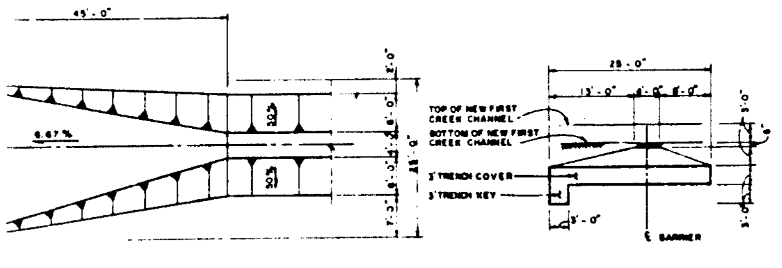


TYPICAL VALVE BOX DETAIL (C / C-2 | C-38)
NO SCALE



BEARING AREA OF BLOCK IN SQ. FT.					
FITTING SIZES	TEE & END	90° BEND	45° BEND	22 1/2° BEND	11 1/4° BEND
6"	5.0	7.2	3.3	2.0	1.1

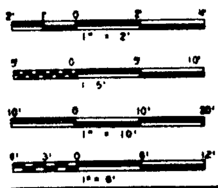
THRUST BLOCKING DETAIL (D / C-2 | C-38)
NO SCALE



SECTION (2)
SCALE: 1" = 10'

TRENCH COVER

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.



THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO   MODIFICATION NO.

DATE	DESCRIPTION	MADE	APPVD
8-13-80	REVISED IN ACCORDANCE WITH AM. NO. 0001		C.O.B

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
MISCELLANEOUS SECTIONS AND DETAILS

DESIGNED BY: Y.M.R.
DRAWN BY: W.L.F.

SCALE: AS SHOWN

DATE: JUNE 1980

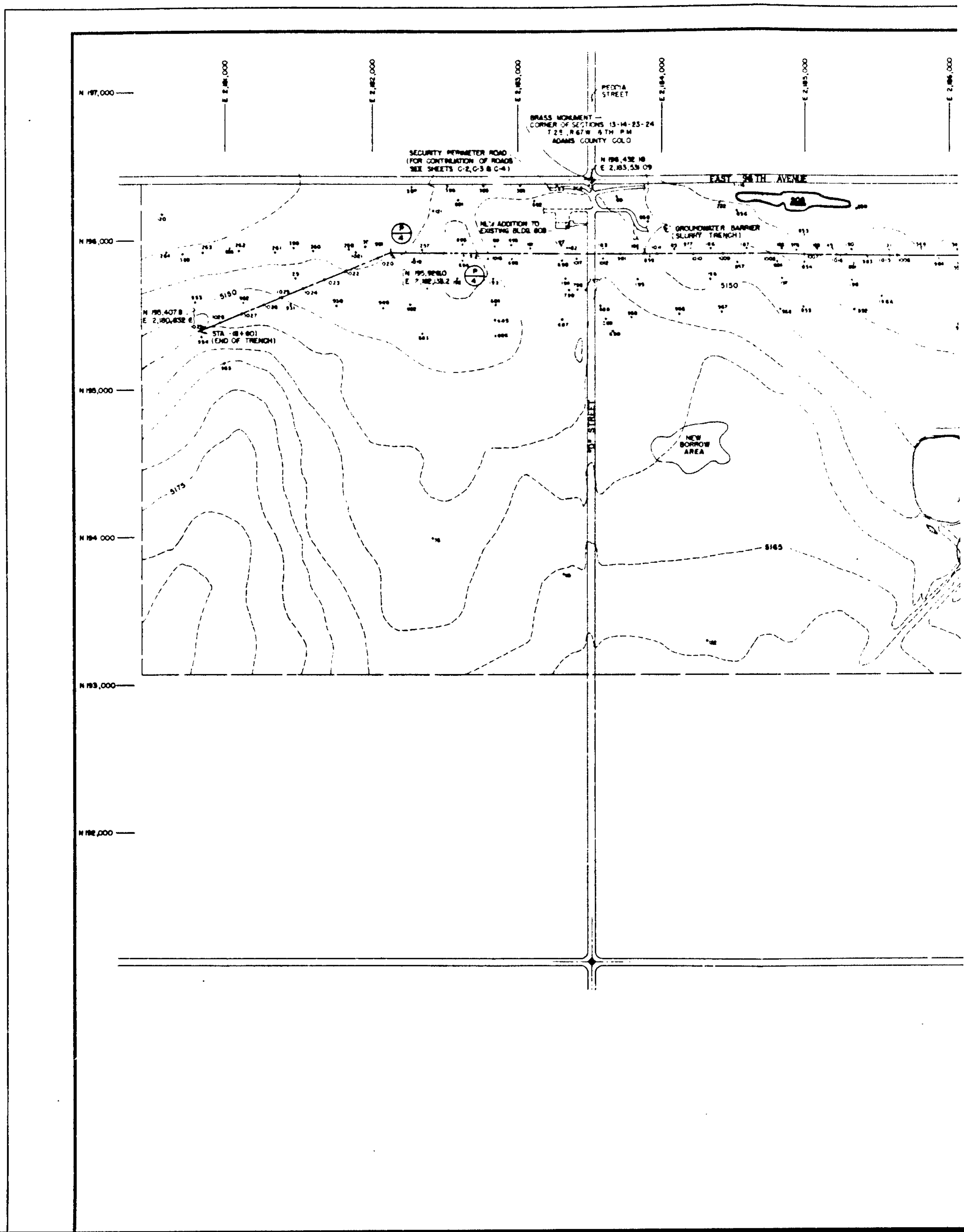
SPEC. NO. DACA45-80-R-0061

71-07-16

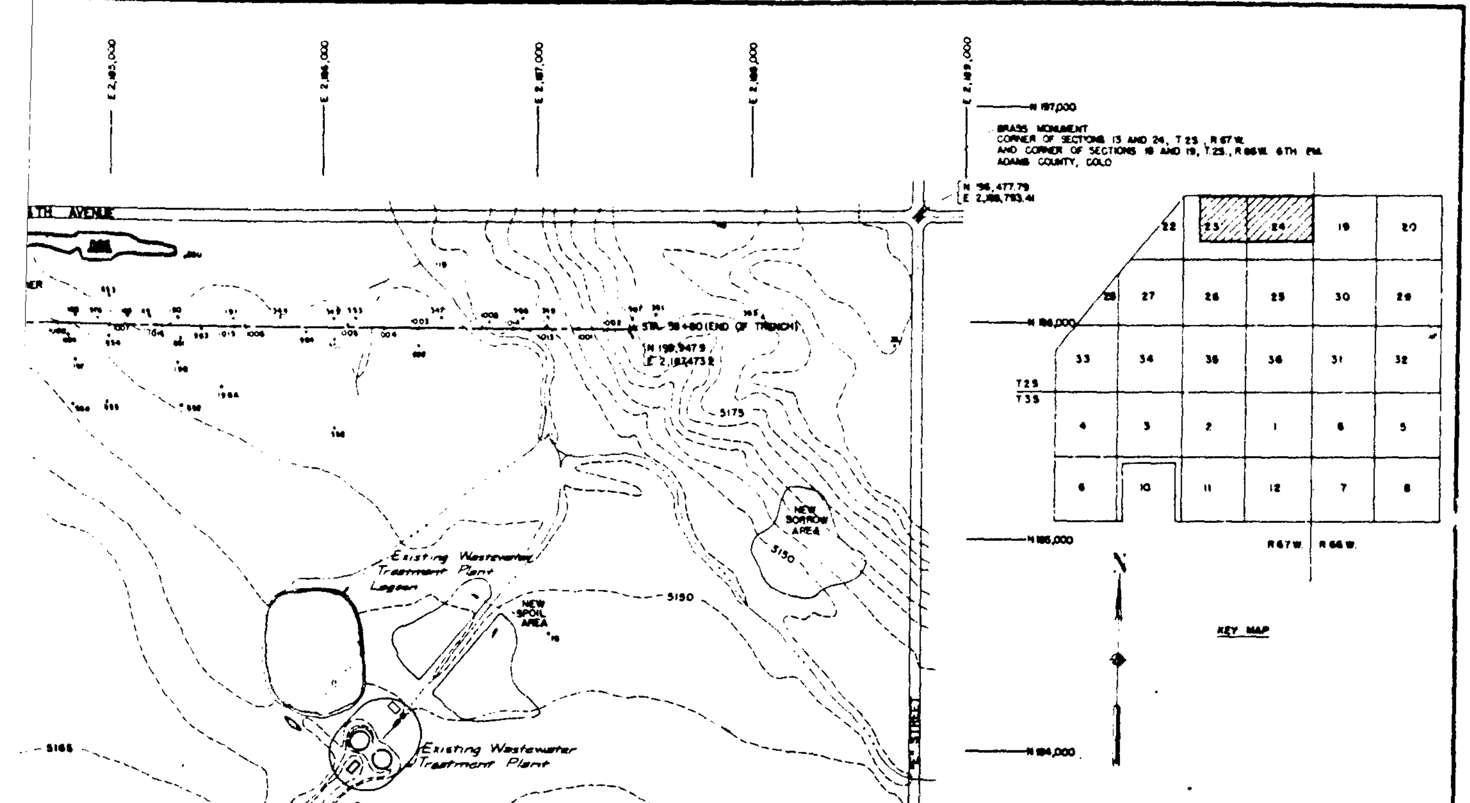
SHEET C-38

PLATE 45

$$ – THINK VALUE ENGINEERING – $$



N 197,000
N 196,000
N 195,000
N 194,000
N 193,000
N 192,000
E 2,181,000
E 2,182,000
E 2,183,000
E 2,184,000
E 2,185,000
E 2,186,000
PEORIA STREET
BRASS MONUMENT — CORNER OF SECTIONS 13-14-23-24 T2S, R67W 6TH PM ADAMS COUNTY COLO
SECURITY PERIMETER ROAD (FOR CONTINUATION OF ROADS SEE SHEETS C-2, C-3 & C-4)
N 196,432.18
E 2,183,531.09
EAST 56TH AVENUE
NEW ADDITION TO EXISTING BLDG 808
GROUNDWATER BARRIER (SLURRY TRENCH)
N 195,407.8
E 2,180,832.6
STA -18+80 (END OF TRENCH)
5150
5175
5165
NEW BORROW AREA



PIEZOMETERS TO BE ABANDONED	
WELL NO.	CASED DEPTH/FT.
885*	67
885*	102
1991*	80
1991*	108
1991*	57
113-2	116
981	93
977*	55
977*	82
976*	71.5
976*	57.2
983	70
984*	58
984*	85
985	63
986	67
987	95

*Indicates cluster wells

N 183,000

N 182,000

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
BORING LOCATION PLAN

DATE JUNE 1980

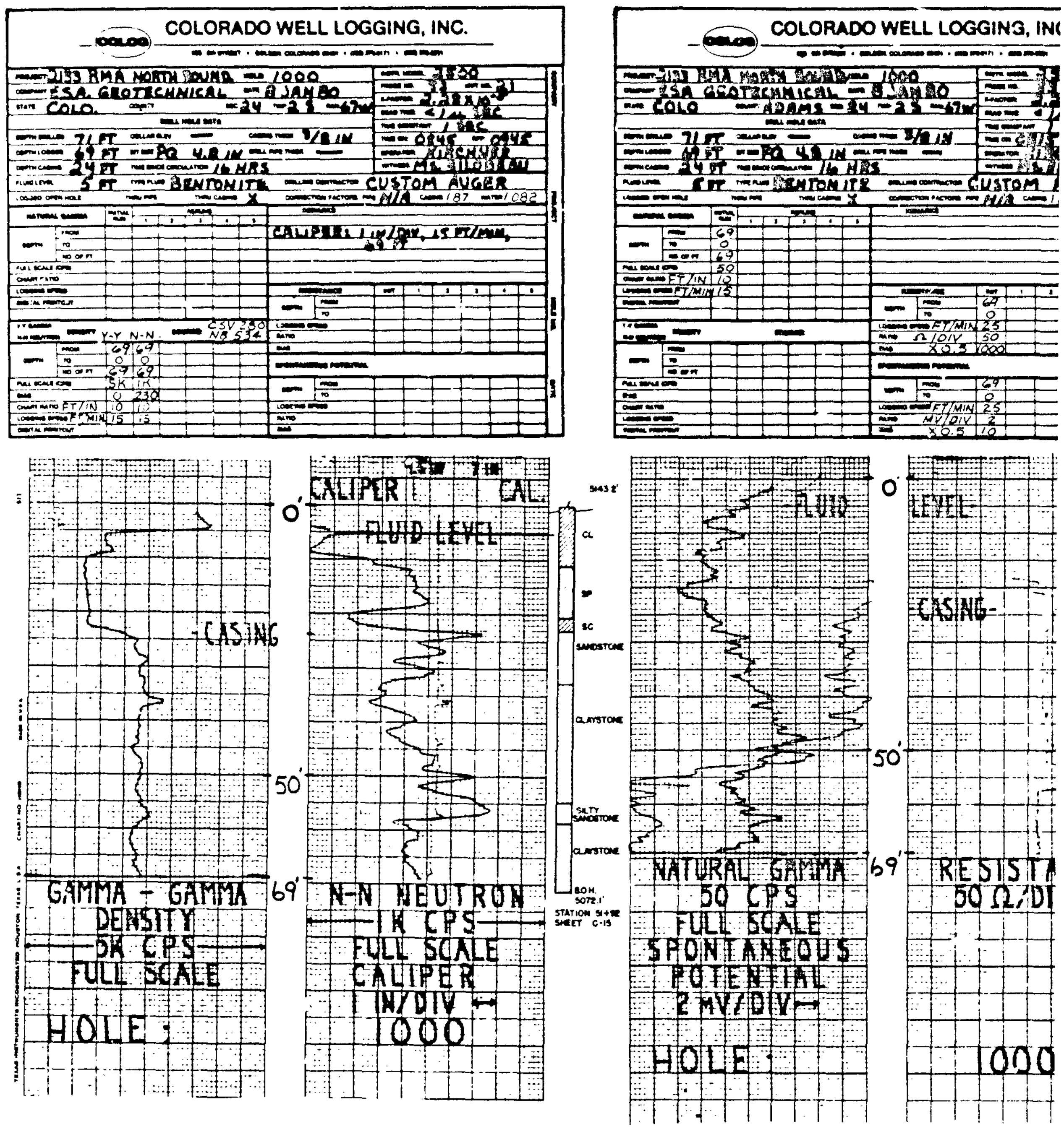
DACA45 80 R 0161

71-07-16

1" = 300'

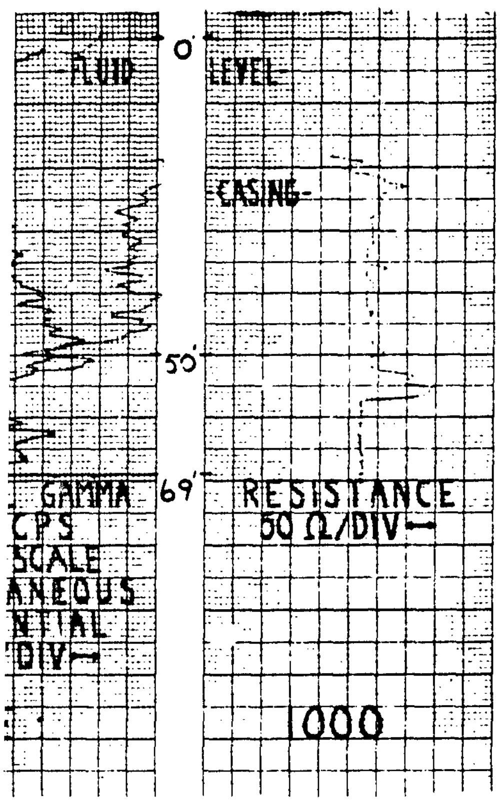
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 81 C0054 MODIFICATION NO. P00004

SAFETY PAYS


COLORADO WELL LOGGING, INC.
2133 RMA NORTH BOUND
1000
ESA GEOTECHNICAL
8 JAN 80
COLO.
ADAMS
24
2 S
67W
71 FT
3/8 IN
69 FT
PQ 4.8 IN
24 FT
16 HRS
5 FT
BENTONITE
CUSTOM AUGER
N/A
KIRCHNER
CALIPER: 1 IN/DIV, 15 FT/MIN, 69 FT
Y-Y N-N
CSV 230
NB 534
69 69
0 0
69 69
5K 1K
0 230
FT/IN 10 10
FT/MIN 15 15
0'
50'
69'
CALIPER
CAL.
FLUID LEVEL
CASING
GAMMA - GAMMA DENSITY
5K CPS
FULL SCALE
HOLE:
N-N NEUTRON
1K CPS
FULL SCALE
CALIPER
1 IN/DIV
1000
5143.2'
CL
SP
SC
SANDSTONE
CLAYSTONE
SILTY SANDSTONE
CLAYSTONE
B.O.H. 5072.1'
STATION 51+92
SHEET C-15
FLUID
LEVEL
CASING
NATURAL GAMMA
50 CPS
FULL SCALE
SPONTANEOUS
POTENTIAL
2 MV/DIV
HOLE:
1000
RESIST
50 Ω/DI
69
0
50
FT/IN 10
FT/MIN 15
FT/MIN 25
Ω/DIV 50
X0.5 1000
MV/DIV 2
X0.5 10

COLORADO WELL LOGGING, INC.

1000
CHEMICAL
6 SAMBO
ADAMS – 24 – 25 – 67W
5/8 IN
4.8 IN
16 HRS
BENTONITE
CUSTOM AUGER
X
N/A
1.87
1.082
69
0
FT/MIN 25
Ω/DIV 50
X0.5 1000
69
0
FT/MIN 25
MV/DIV 2
X0.5 10



GENERAL NOTES:

1 WHERE THE SAMPLE TESTED HAD OVER 25% PASSING THE NO 200 WASH THEN THE MECHANICAL SIEVE ANALYSIS WAS NOT RUN. THIS WAS BASED ON THE CRITERIA THAT SOIL HAVING GREATER THAN 25% PASSING THE NO 200 WASH WOULD NOT BE ACCEPTABLE FOR SAND BACKFILL IN THE TRENCH

PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH		GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.5-5.0 N=4													
8.5-10.0 N=7	36.0% PASSING												
13.5-15.0 N=10	2.9% PASSING	% PASSING				100	99.9	98.1	94.5	41.4	12.9	5.4	3.5
18.5-20.0 N=23													
23.5-23.9 N=100/5" BEGAN CORING AT 23.9' FT													

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

GEOPHYSICAL BORING LOGS SHEET 1 OF 30

JUNE 1, 80

DACA45 & R 3161

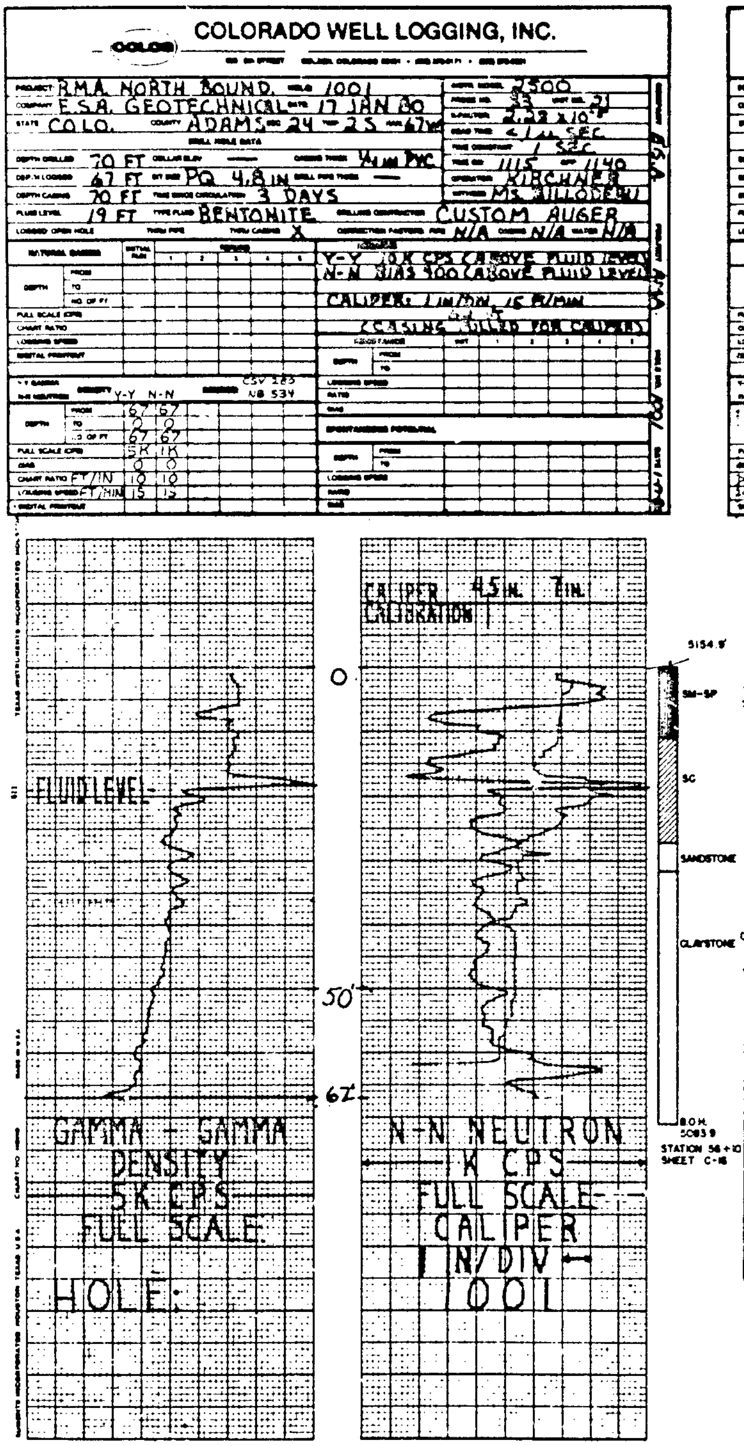
71-07-16

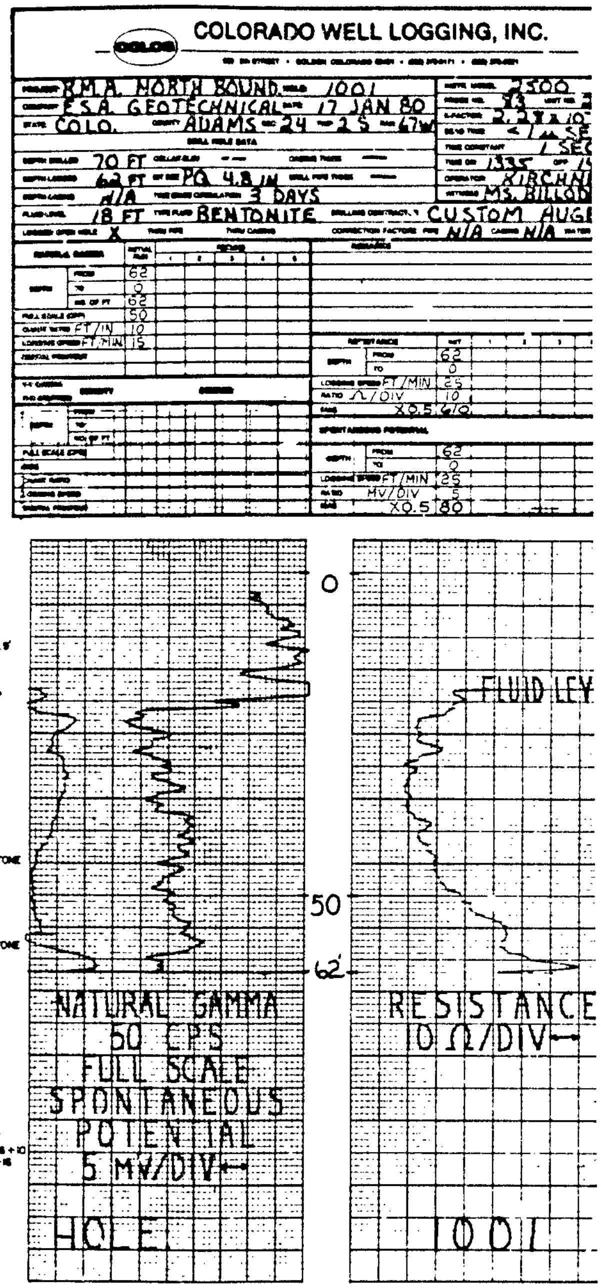
C-40

SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO SPECIFICATION NO.

$$ – THINK VALUE ENGINEERING – $$


COLORADO WELL LOGGING, INC.
RMA NORTH BOUND
1001
E.S.A. GEOTECHNICAL
17 JAN 80
COLO.
ADAMS
24
2S
67W
2500
70 FT
67 FT
PQ 4.8 IN
70 FT
3 DAYS
19 FT
BENTONITE
CUSTOM AUGER
KIRCHNER
N/A
Y-Y
N-N
CALIPER 4.5IN. 7IN.
CALIBRATION
0
FLUID LEVEL
50'
62'
GAMMA - GAMMA
DENSITY
5K CPS
FULL SCALE
HOLE
N-N NEUTRON
1K CPS
FULL SCALE
CALIPER
1 IN/DIV
1001
5154.9'
SM-SP
SC
SANDSTONE
CLAYSTONE
B.O.H.
5083.9
STATION 56+10
SHEET C-16


COLORADO WELL LOGGING, INC.
RMA NORTH BOUND
1001
E.S.A. GEOTECHNICAL
17 JAN 80
COLO.
ADAMS
24
2S
67W
2500
70 FT
62 FT
PQ 4.8 IN
N/A
3 DAYS
18 FT
BENTONITE
CUSTOM AUGER
KIRCHNER
MS. BILLOD
N/A
0
FLUID LEVEL
50
62'
NATURAL GAMMA
50 CPS
FULL SCALE
SPONTANEOUS
POTENTIAL
5 MV/DIV
HOLE
RESISTANCE
10 Ω/DIV
1001

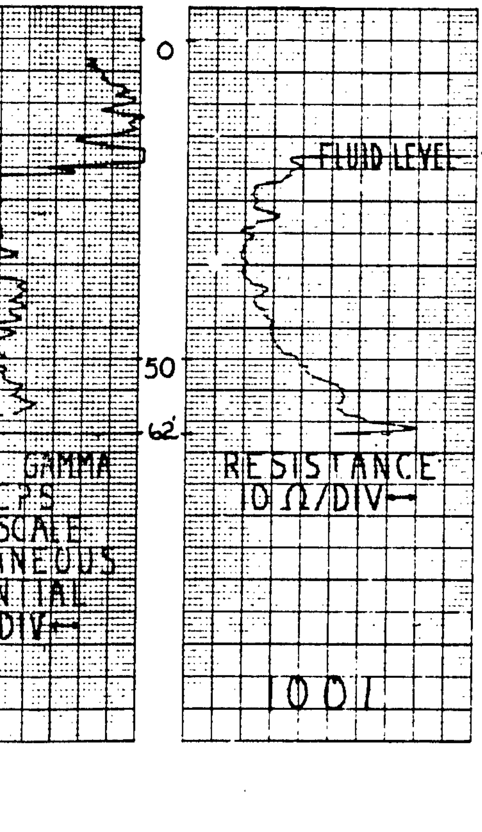
COLORADO WELL LOGGING, INC.

RTH BOUND	1001
TECHNICAL	17 JAN 80
ADAMS	24 - 2 S - 67W
PQ 4.8 IN	
3 DAYS	
BENTONITE	CUSTOM AUGER
	2500
	33 / 21
	2.3 x 10[-6]
	< 1 μ SEC
	1 SEC
	1335 / 1410
	KIRCHNER
	MS. BILLODEAU
CORRECTION FACTORS	N/A / N/A / N/A

DEPTH FROM	62
TO	0
LOGGING SPEED FT/MIN	25
RATIO Ω/DIV	10
	X0.5 6/0

DEPTH FROM	62
TO	0
LOGGING SPEED FT/MIN	25
RATIO MV/DIV	5
	X0.5 80

ESA RMA 1001 1-17



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.0-4.5 N=7	28.7 PASSING											
8.0-9.5 N=5												
13.0-14.5 N=13	43.3 PASSING											
18.0-19.5 N=22												
23.0-24.5 N=23												
28.0-29.0 N=135/12" BEGAN CORING AT 29.0 FT.												

(GRADATION SIEVE SIZES: 1" 3/4" 1/2" 3/8" #4 #10 #20 #40 #60 #100 #200)

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U.S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

GEOPHYSICAL BORING LOGS SHEET 2 OF 30

JUNE 1980

71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45-7 C0 SPECIFICATION NO.

SAFETY PAYS

COLORADO WELL LOGGING, INC. (COLOG)

PROJECT	R.M.A. NORTH BOUND	HOLE	1002
COMPANY	E.S.A. GEOTECHNICAL	DATE	17 JAN 80
STATE	COLO.	COUNTY	ADAMS SEC 24 TWP 2 S RGE 67W
METER MODEL	2500	PROBE NO / UNIT NO	93 / 21
K-FACTOR	2.28 x 10	DEAD TIME	< 1 μ SEC
TIME CONSTANT	1 SEC	TIME ON / OFF	1445 / 1520
OPERATOR	KIRCHNER	WITNESS	MS. BILLODEAU
DEPTH DRILLED	70 FT	DEPTH LOGGED	64 FT
BIT SIZE	PQ 4.8 IN	TIME SINCE CIRCULATION	4 DAYS
FLUID LEVEL	24 FT	TYPE FLUID	BENTONITE
DRILLING CONTRACTOR	CUSTOM AUGER	LOGGED OPEN HOLE	X
CORRECTION FACTORS	PIPE N/A	CASING N/A	WATER N/A

REMARKS: N-N 2K CPS BIAS 1000 (ABOVE FLUID LEVEL). CALIPER: 1 IN/DIV, 15 FT/MIN

	Y-Y	N-N
SOURCE	CSV 280	NB 534
DEPTH FROM	64	64
TO	0	0
NO OF FT	64	64
FULL SCALE (CPS)	10K	1K
BIAS	0	160
CHART RATIO FT/IN	10	10
LOGGING SPEED FT/MIN	15	15

COMPANY E.S.A. PROJECT R.M.A. HOLE NO 1002 DATE 1-17-80

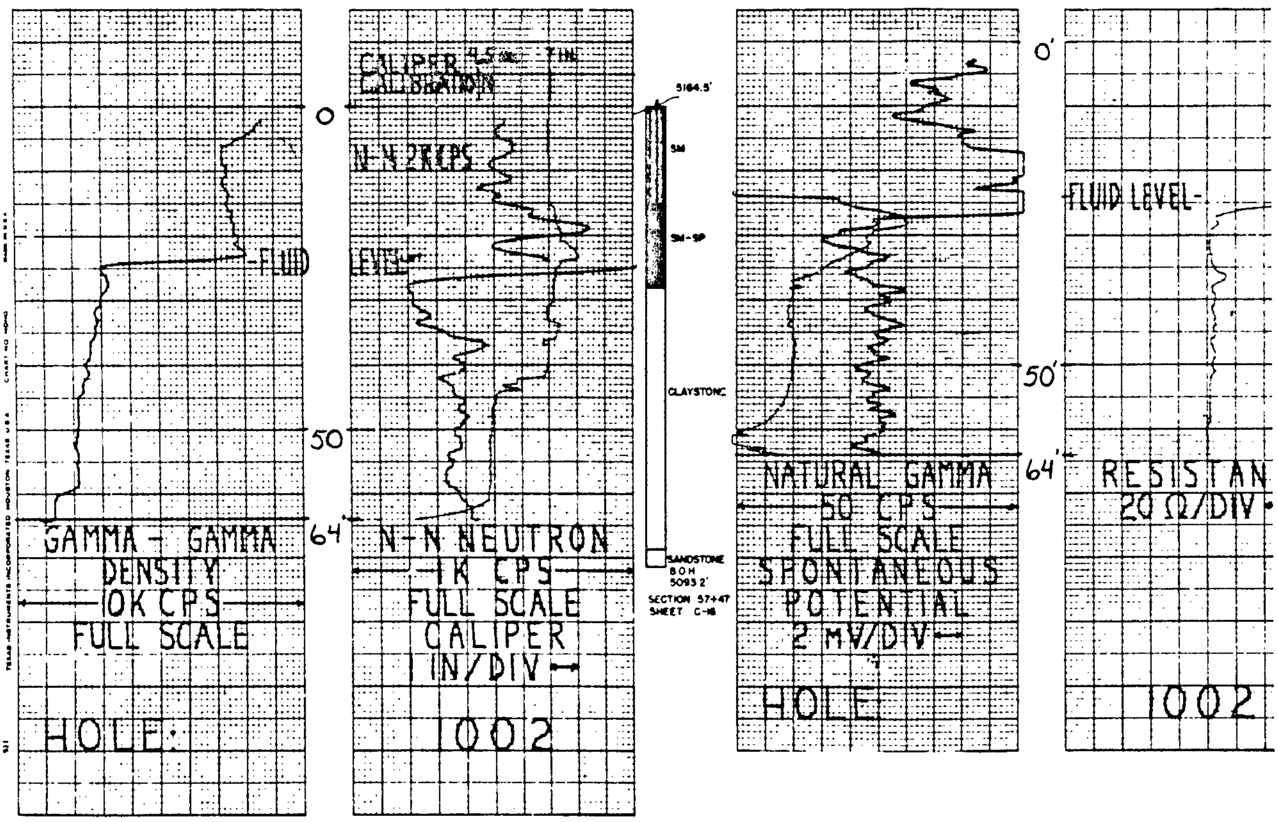
COLORADO WELL LOGGING, INC. (COLOG)

PROJECT	R.M.A. NORTH BOUND	HOLE	1002
COMPANY	E.S.A. GEOTECHNICAL	DATE	17 JAN 80
STATE	COLO.	COUNTY	ADAMS SEC 24 TWP 2 S RGE 67W
METER MODEL	2500	PROBE NO	93
K-FACTOR	2.28 x	DEAD TIME	< 1 μ
TIME CONSTANT	1 S	TIME ON	1420
OPERATOR	KIRCH	WITNESS	MS. BILL
DEPTH DRILLED	70 FT	DEPTH LOGGED	64 FT
BIT SIZE	PQ 4.8 IN	TIME SINCE CIRCULATION	4 DAYS
FLUID LEVEL	24 FT	TYPE FLUID	BENTONITE
DRILLING CONTRACTOR	CUSTOM AU	LOGGED OPEN HOLE	X
CORRECTION FACTORS	PIPE N/A	CASING N/A	

NATURAL GAMMA	
DEPTH FROM	64
TO	0
NO OF FT	64
FULL SCALE (CPS)	50
CHART RATIO FT/IN	10
LOGGING SPEED FT/MIN	15

RESISTANCE	
DEPTH FROM	64
TO	0
LOGGING SPEED FT/IN	25
RATIO Ω/DIV	20
BIAS x0.5	1000

SPONTANEOUS POTENTIAL	
DEPTH FROM	64
TO	0
LOGGING SPEED FT/IN	25
RATIO mV/DIV	2
BIAS x0.5	30



COLORADO WELL LOGGING, INC.

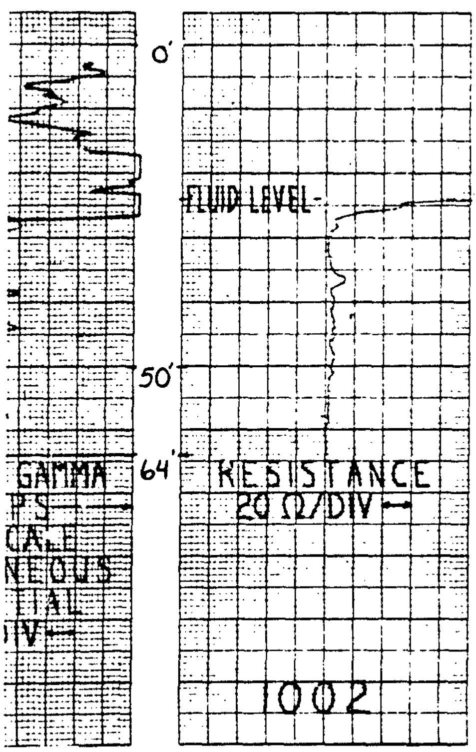
H BOUND HOLE 1002
CHNICAL DATE 17 JAN 80
ADAMS SEC 24 TWP 2 S RNG 67 W
DRILL HOLE DATA
?Q 4.8 IN
CIRCULATION 4 DAYS
BENTONITE DRILLING CONTRACTOR CUSTOM AUGER
CORRECTION FACTORS N/A CASING N/A WATER N/A

METER MODEL 2500
PROBE NO 13 UNIT NO 21
K-FACTOR 2.21 x 10
DEAD TIME < 1 μ SEC
TIME CONSTANT 1 SEC
TIME ON 1420 OFF 1440
OPERATOR KIRCHNER
WITNESS MS. BILLODEAU

COMPANY E.S.A.
PROJECT R.M.A.
HOLE NO 1002

RESISTANCE		RUN
DEPTH	FROM	64
	TO	0
LOGGING SPEED	FT/MIN	25
RATIO	Ω/DIV	20
BIAS	X0.5	1000

DEPTH	FROM	64
	TO	0
LOGGING SPEED	FT/IN	25
RATIO	mV/DIV	5
BIAS	X0.5	30



PENETRATION NO	GRADATION RESULTS % PASSING NO 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.0-4.5 N=25												
8.0-9.5 N=27	50.0 % PASSING											
13.0-14.5 N=47												
18.0-19.5 N=30												
23.0-24.5 N=23	5.2 % PASSING	% PASSING →			100	99.9	97.1	73.0	31.6	11.4	7.1	5.5
28.0-29.5 N=30												
33.0-34.5 N=45												
38.0-39.5 N=59												
43.0-44.5 N=57												

BEGAN CORING AT 45.5 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MARK	APPR'D

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

GEOPHYSICAL BORING LOGS SHEET 3 OF 30

SAFETY PAYS

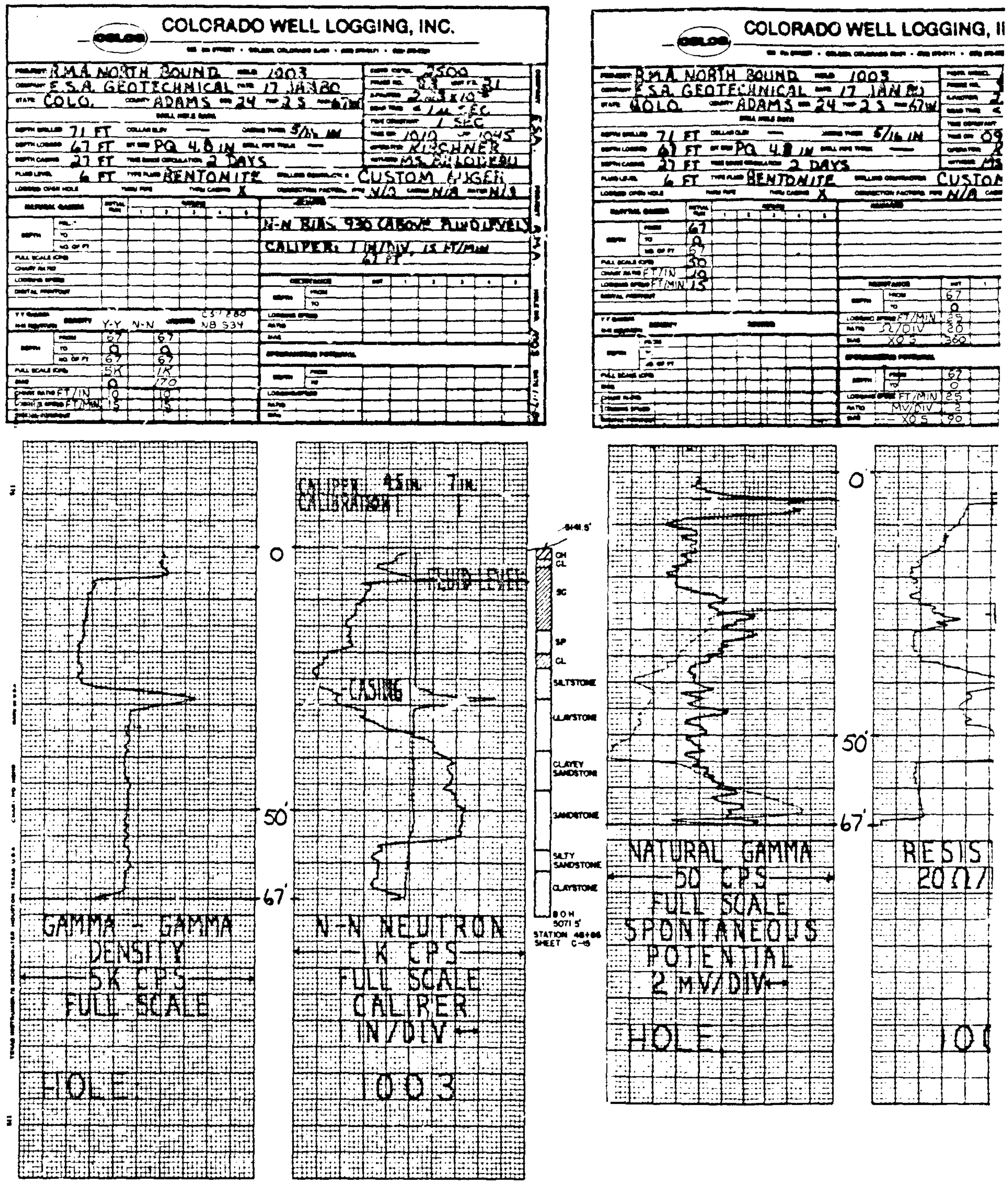
JUNE 1980

DACA45-R-.161

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45-7 CO

71-07-16

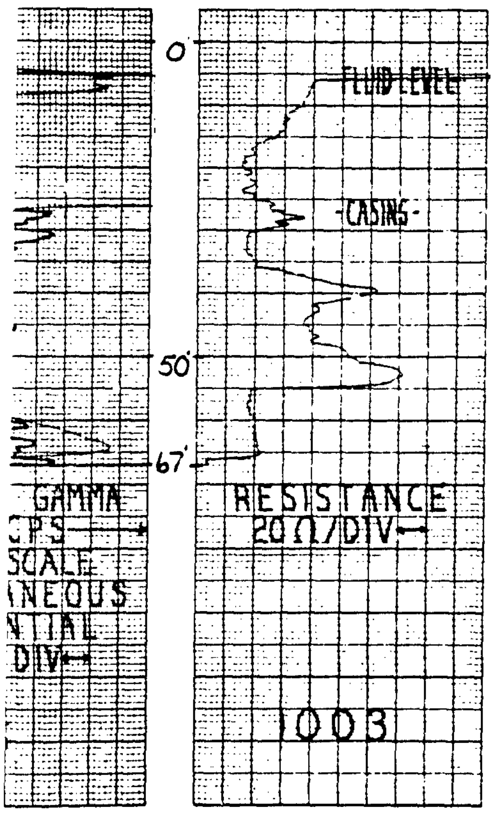
C-49


COLORADO WELL LOGGING, INC.
RMA NORTH BOUND
1003
E.S.A. GEOTECHNICAL
17 JAN 80
COLO.
ADAMS
24
2 S
67W
71 FT
67 FT
PQ 4.8 IN
27 FT
2 DAYS
6 FT
BENTONITE
CUSTOM AUGER
KIRCHNER
N-N BIAS 930 (ABOVE FLUID LEVEL)
CALIPER: 1 IN/DIV, 15 FT/MIN
CALIPER: 4.5 IN. 7 IN.
CALIBRATION
0
FLUID LEVEL
CASING
50'
67'
GAMMA - GAMMA
DENSITY
5K CPS
FULL SCALE
N-N NEUTRON
1K CPS
FULL SCALE
CALIPER
1 IN/DIV
HOLE 1003
SILTSTONE
CLAYSTONE
CLAYEY SANDSTONE
SANDSTONE
SILTY SANDSTONE
CLAYSTONE
BOH
5071.5'
STATION 48+86
SHEET C-15
NATURAL GAMMA
50 CPS
FULL SCALE
SPONTANEOUS
POTENTIAL
2 MV/DIV
HOLE
RESIS
20 Ω/

COLORADO WELL LOGGING, INC.

BOUND 1003
CHNICAL 17 JAN 80
ADAMS 24 2 S 67W
5/16 IN
PQ 4.8 IN
2 DAYS
BENTONITE CUSTOM AUGER
X N/A N/A N/A
2500
53 21
2.38 X10
< 1/4 SEC
1 SEC
0940 1000
KIRCHNER
Mr. BILLODEAU

67	
0	
FT/MIN	25
Ω/DIV	20
XO.5	360
67	
0	
FT/MIN	25
MV/DIV	2
XO.5	90



PENETRATION NO.		GRADATION RESULTS % PASSING NO. 200 WASH		1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.5–5.0	N=4	61.3% PASSING												
8.5–10.0	N=13													
13.5–15.0	N=8													
18.5–20.0	N=16	15.4% PASSING	% PASSING ——				100	98.1	91.8	68.2	40.0	25.7	19.2	16.2
23.5–25.0	N=27													
28.5–29.5	N=33/12"													

BEGAN CORING AT 30.0 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 4 OF 30

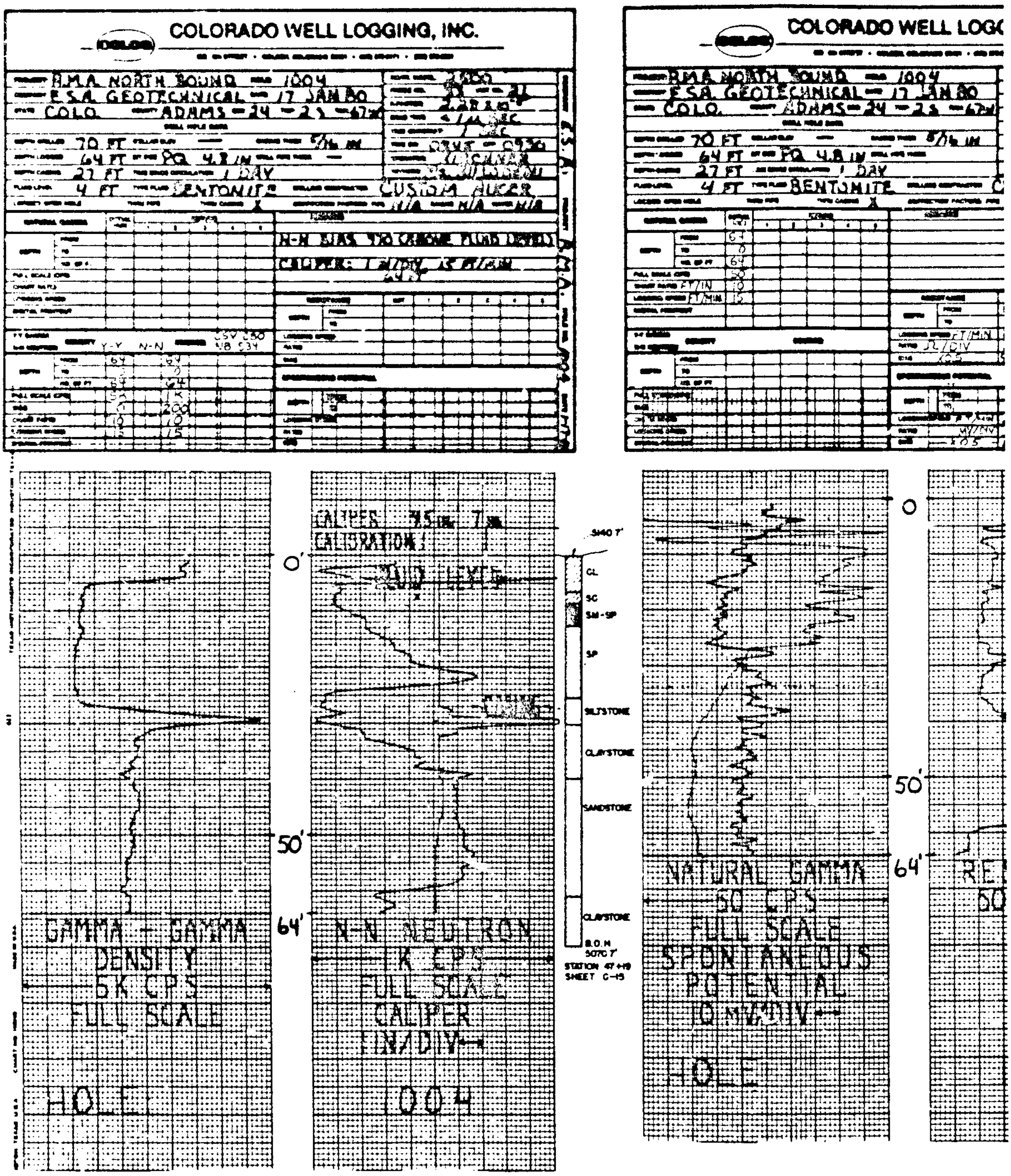
JUNE 1980

R 3161

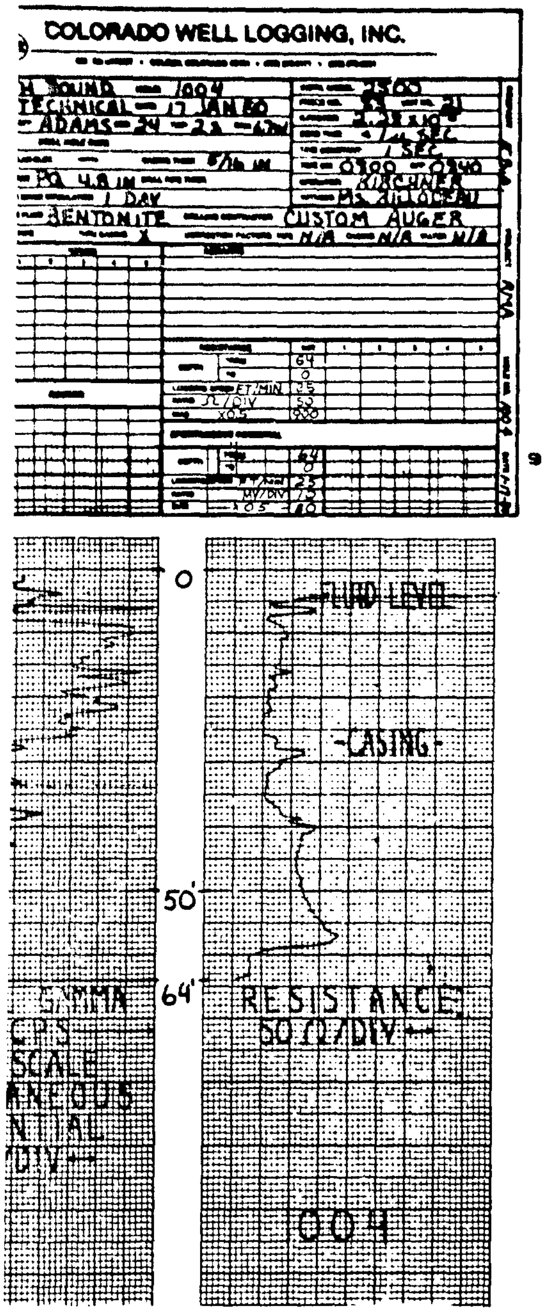
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 ? 80

71-07-16

SAFETY PAYS



COLORADO WELL LOGGING, INC.
RMA NORTH BOUND 1004
ESA GEOTECHNICAL 17 JAN 80
COLO. ADAMS 24 2S 67W
70 FT
64 FT PQ 4.8 IN
27 FT 1 DAY
4 FT BENTONITE CUSTOM AUGER
N/A N/A N/A
N-N BIAS 930 CHROME FLUID LEVEL
CALIPER: 1 IN/DIV 15 FT/MIN
Y-Y N-N
CALIPER 3.5 IN 7 IN
CALIBRATION!
FLUID LEVEL
0'
50'
64'
CL
SC
SM-SP
SP
SILTSTONE
CLAYSTONE
SANDSTONE
CLAYSTONE
STATION 47+10
SHEET C-15
GAMMA - GAMMA DENSITY 5K CPS FULL SCALE
HOLE
N-N NEUTRON K CPS FULL SCALE
CALIPER 1 IN/DIV
004
NATURAL GAMMA 50 CPS FULL SCALE
SPONTANEOUS POTENTIAL 10 MV/DIV
HOLE
COLORADO WELL LOG



PENETRATION NO.		GRADATION RESULTS % PASSING NO. 200 WASH	GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
30-45	N=6	63.7 % PASSING											
80-95	N=16												
130-145	N=16												
180-195	N=20												
230-245	N=22	8.2 % PASSING	100	97.2	92.1	88.1	80.2	61.8	38.2	24.1	16.5	12.1	9.3
280-290	N=83+/6"												

BEGAN CORING AT 300 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 5 OF 30

JUNE 1964

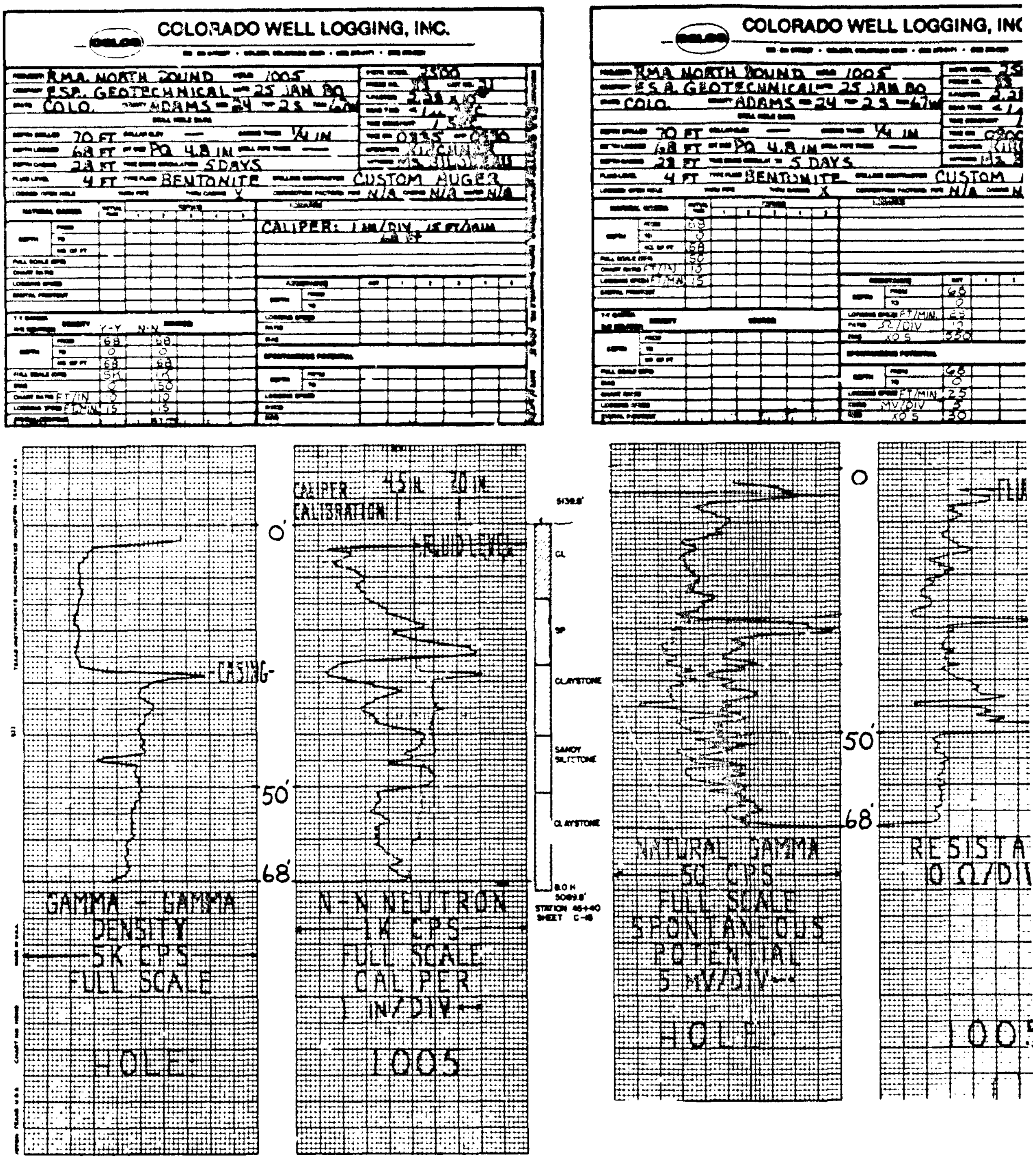
DACA45 … R 0161

71-07-16

C-44

SAFETY PAYS

TULSA PLAN ABBREVIATED CONTRACT NO. DACA 45-7 CO



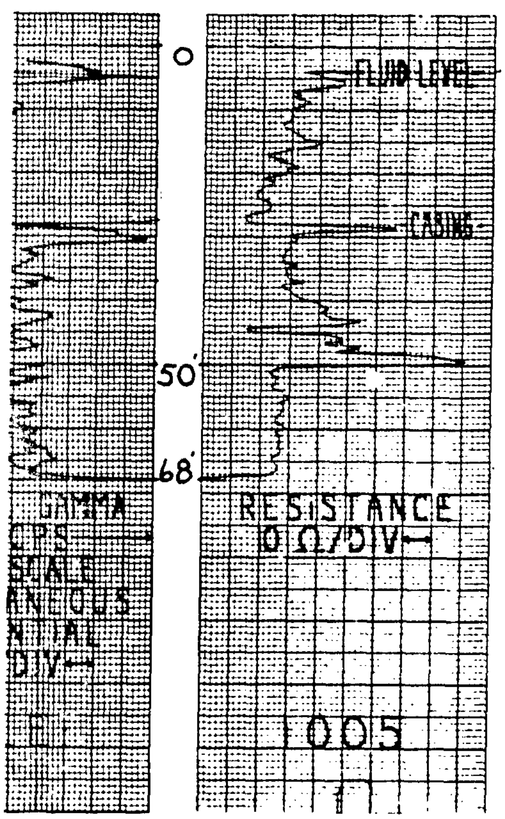
COLORADO WELL LOGGING, INC.
RMA NORTH BOUND 1005
ESE GEOTECHNICAL 25 JAN 80
COLO. ADAMS
70 FT
68 FT PQ 4.8 IN
28 FT 5 DAYS
4 FT BENTONITE CUSTOM AUGER
CALIPER: 1 IN/DIV
COLORADO WELL LOGGING, INC
RMA NORTH BOUND 1005
ESE GEOTECHNICAL 25 JAN 80
COLO. ADAMS
70 FT
68 FT PQ 4.8 IN
28 FT 5 DAYS
4 FT BENTONITE CUSTOM
CALIPER 4.5 IN 7.0 IN
CALIBRATION
FLUID LEVEL
CASING
0'
50'
68'
CL
SP
CLAYSTONE
SANDY SILTSTONE
CLAYSTONE
STATION 464+40
SHEET C-16
GAMMA - GAMMA
DENSITY
5K CPS
FULL SCALE
HOLE
N-N NEUTRON
1K CPS
FULL SCALE
CALIPER
1 IN/DIV
1005
NATURAL GAMMA
50 CPS
FULL SCALE
SPONTANEOUS
POTENTIAL
5 MV/DIV
HOLE
RESISTA
10 Ω/DI
100

COLORADO WELL LOGGING, INC.

H SOUND 1005 — 3500
TECHNICAL 25 JAN 80
ADAMS 24 2S 67W
2.28 x 10
<1 μ SEC
1 SEC
¼ IN
0800 — 0835
PQ 4.8 IN — KIRCHNER
5 DAYS — Mr BILODEAU
BENTONITE — CUSTOM AUGER
X — N/A N/A N/A

68 / 0 — FT/MIN 25 — 32/DIV — X0.5 — 330

68 / 0 — FT/MIN 25 — MV/DIV — X0.5 — 30



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.5-5.0 N=2	53.7% PASSING											
8.5-10.0 N=8												
13.5-15.0 N=7												
18.5-20.0 N=9												
23.5-25.0 N=52	6.3% PASSING	100	83.1	75.1	70.5	59.7	44.8	31.1	19.8	13.1	9.2	7.2
28.5-30.0 N=29 BEGAN CORING AT 32.0 FT.												

(GRADATION SIEVE SIZES: 1" through #200)

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION GEOPHYSICAL BORING LOGS SHEET 6 OF 30

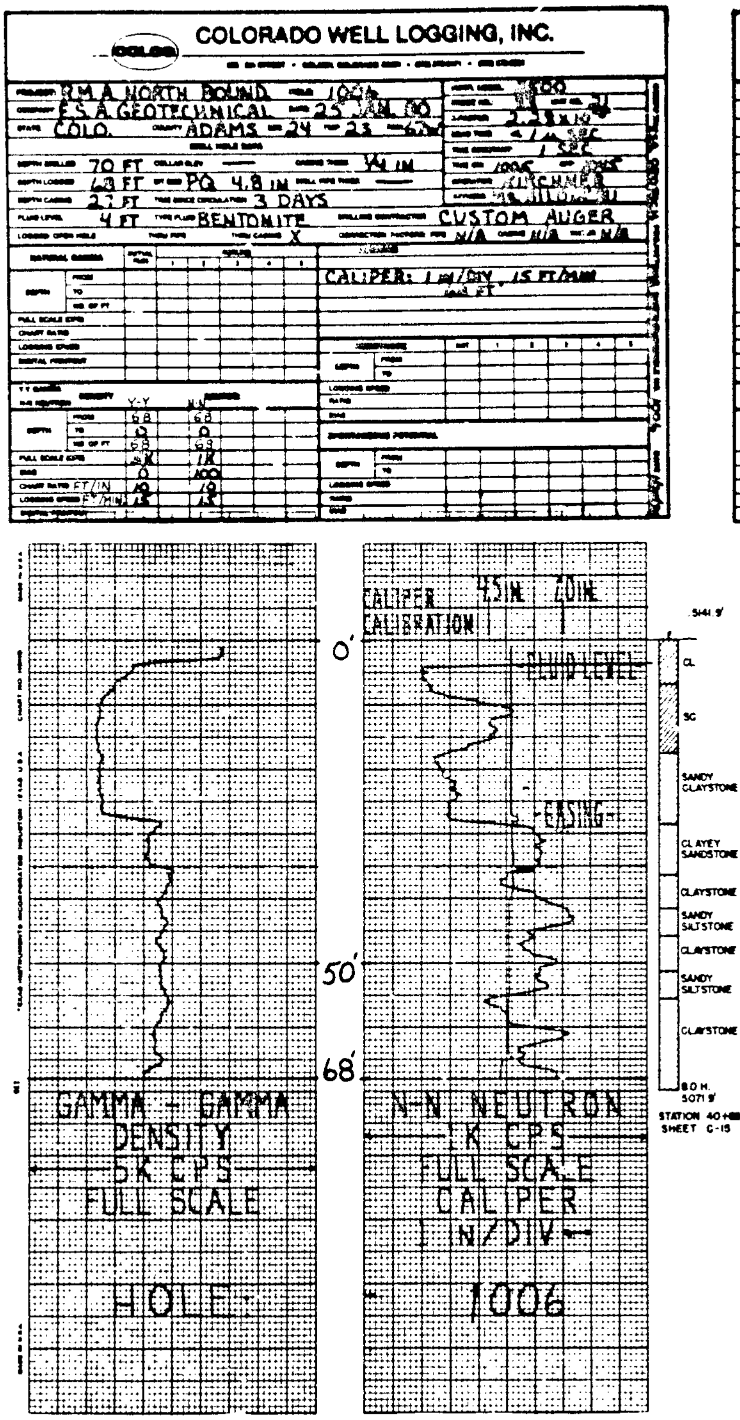
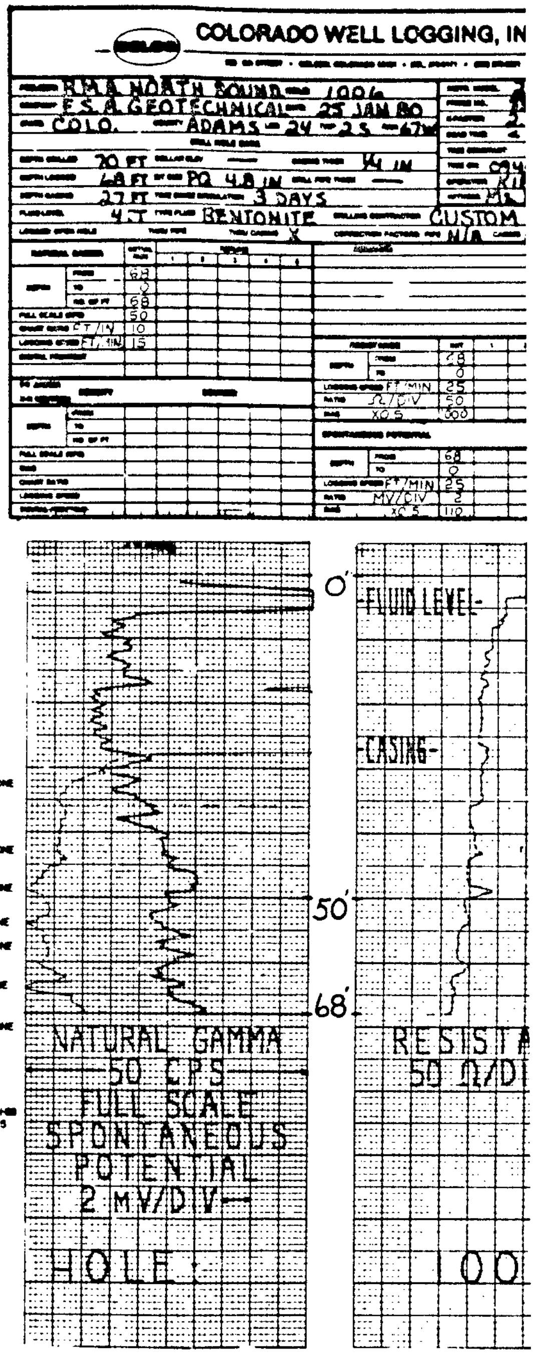
JUNE 1980

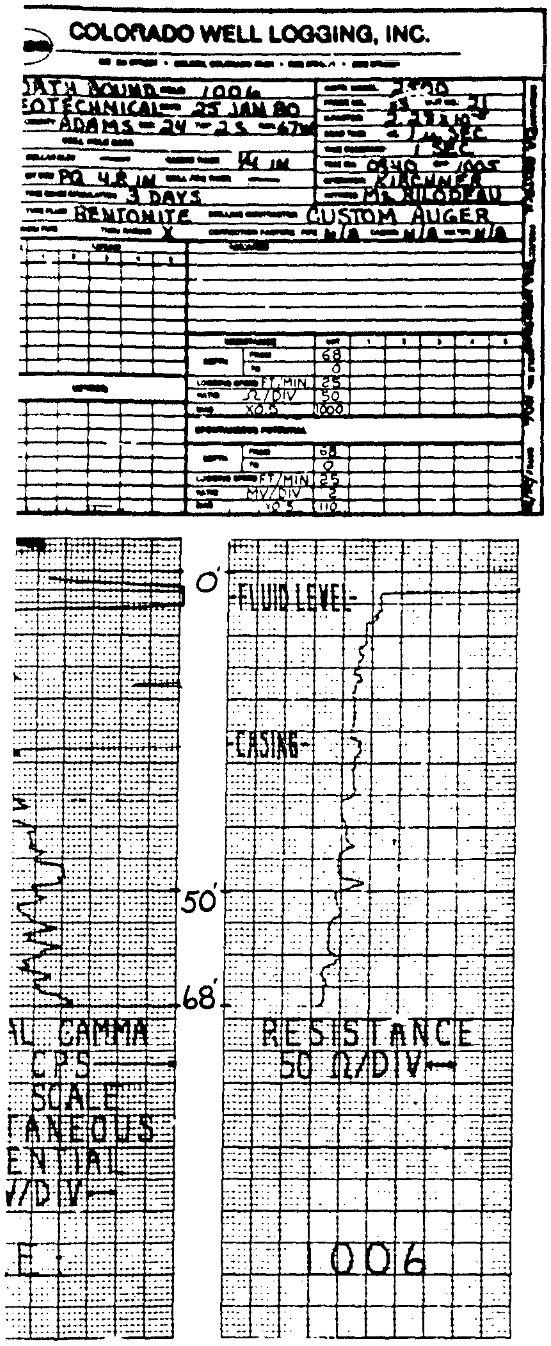
R 3161

71-07-16

SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45-? ?0


COLORADO WELL LOGGING, INC.
RMA NORTH BOUND 1006
ESA GEOTECHNICAL 25 JAN 80
COLO. ADAMS 24 23 67W
70 FT
68 FT PQ 4.8 IN
27 FT 3 DAYS
4 FT BENTONITE CUSTOM AUGER
N/A N/A N/A
CALIPER: 1 IN/DIV, 15 FT/MIN
Y-Y N-N
68 68
0 0
68 68
FT/IN
FT/MIN
CALIPER CALIBRATION 4.5IN 2.0IN
0'
FLUID LEVEL
CASING
50'
68'
CL
SC
SANDY CLAYSTONE
CLAYEY SANDSTONE
CLAYSTONE
SANDY SILTSTONE
CLAYSTONE
SANDY SILTSTONE
CLAYSTONE
STATION 40+00
SHEET C-15
GAMMA - GAMMA DENSITY 5K CPS FULL SCALE
N-N NEUTRON 1K CPS FULL SCALE CALIPER 1 IN/DIV
HOLE: 1006

COLORADO WELL LOGGING, IN
RMA NORTH BOUND 1006
ESA GEOTECHNICAL 25 JAN 80
COLO. ADAMS 24 23 67W
70 FT
68 FT PQ 4.8 IN
27 FT 3 DAYS
4 FT BENTONITE CUSTOM
N/A
68
0
68
50
FT/IN 10
FT/MIN 15
68
0
FT/MIN 25
Ω/DIV 50
X0.5 500
68
0
FT/MIN 25
MV/DIV 2
X0.5 110
0'
FLUID LEVEL
CASING
50'
68'
NATURAL GAMMA 50 CPS FULL SCALE SPONTANEOUS POTENTIAL 2 MV/DIV
HOLE:
RESIST
50 Ω/D
100



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.0-4.5 N=4	66.6 % PASSING											
8.0-9.5 N=10	17.9 % PASSING	% PASSING			100	99.3	98.6	87.1	57.1	34.8	24.5	18.3
13.0-14.5 N=23												
18.0-19.5 N=41												
23.0-24.5 N=127												
28.0-29.0 N=140/12"												

BEGAN CORING AT 29.5' FT.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

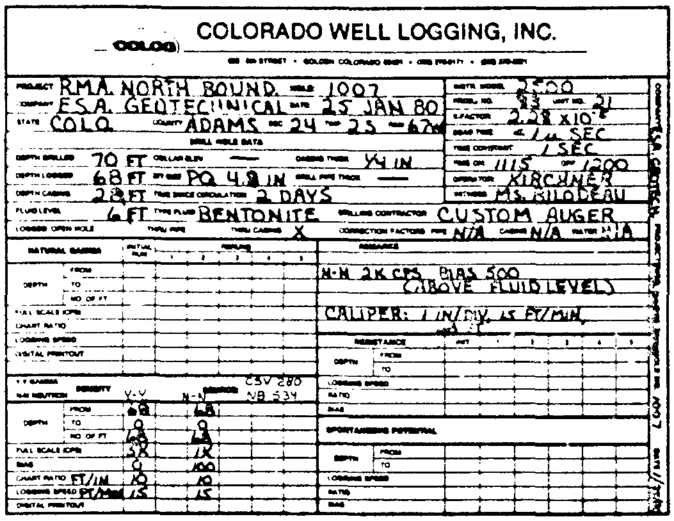
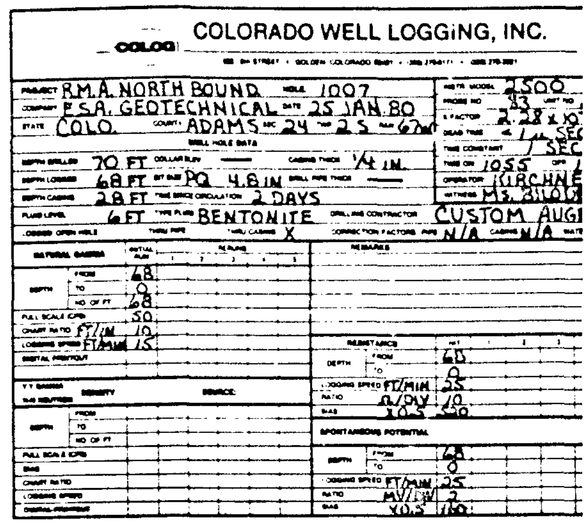
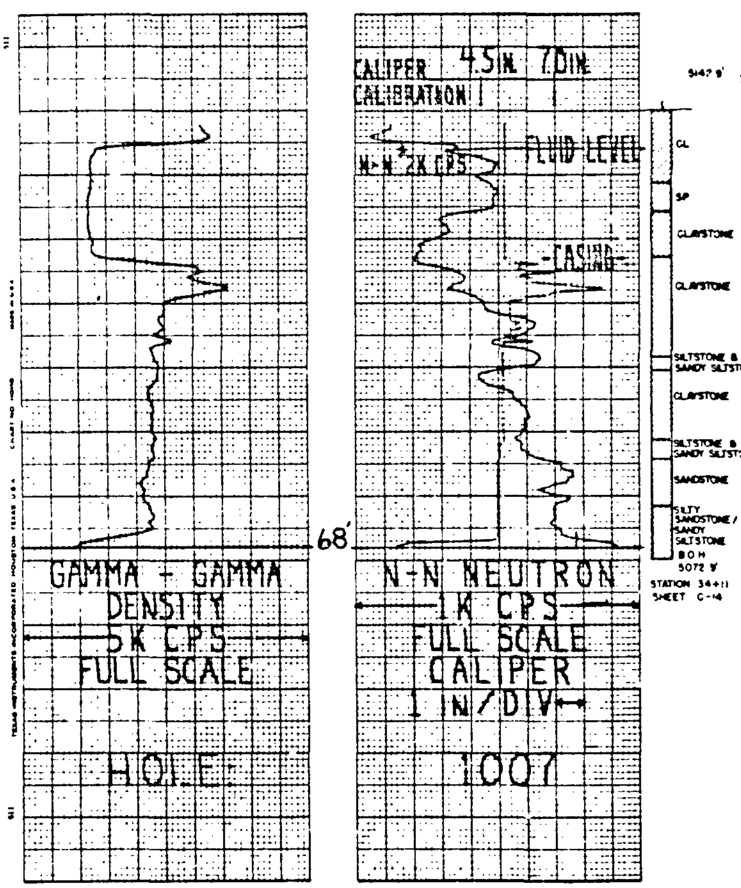
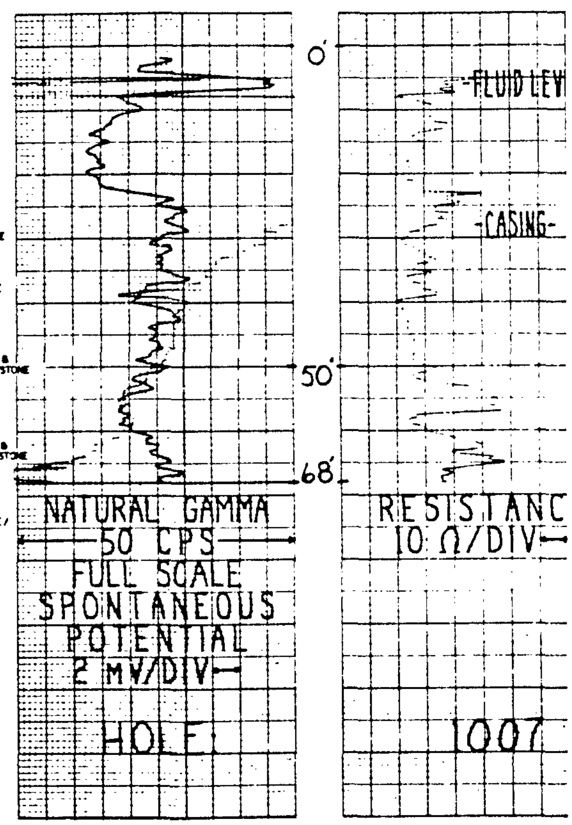
ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 7 OF 30

JUNE 1980

71-07-16

$$ — THINK VALUE ENGINEERING — $$


COLOG
COLORADO WELL LOGGING, INC.
RMA NORTH BOUND
1007
E.S.A. GEOTECHNICAL
25 JAN 80
COLO
ADAMS
24
2 S
67W
70 FT
1/4 IN
68 FT
PQ 4.8 IN
28 FT
2 DAYS
6 FT
BENTONITE
CUSTOM AUGER
KIRCHNER
MS. BILODEAU
N/A
N-N 2K CPS BIAS 500
(ABOVE FLUID LEVEL)
CALIPER: 1 IN/DIV, 15 FT/MIN
CSV 280
NB 534
V-V
N-N
68
0
68
5K
1K
0
100
FT/IN
10
10
FT/MIN
15
15

COLOG
COLORADO WELL LOGGING, INC.
RM.A. NORTH BOUND
1007
E.S.A. GEOTECHNICAL
25 JAN 80
COLO.
ADAMS
24
2 S
67W
70 FT
1/4 IN.
68 FT
PQ 4.8 IN
28 FT
2 DAYS
6 FT
BENTONITE
CUSTOM AUG
KIRCHNE
MS. BILOD
X
N/A
N/A
68
0
68
50
FT/IN 10
FT/MIN 15
68
0
FT/MIN 25
Ω/DIV 10
68
0
FT/MIN 25
MV/DIV 2

CALIPER 4.5IN 7.0IN
CALIBRATION
N-N 2K CPS
FLUID LEVEL
-CASING-
CL
SP
CLAYSTONE
CLAYSTONE
SILTSTONE & SANDY SILTSTONE
CLAYSTONE
SILTSTONE & SANDY SILTSTONE
SANDSTONE
SILTY SANDSTONE / SANDY SILTSTONE
BOH
5072.9
STATION 34+11
SHEET C-14
68'
GAMMA - GAMMA
DENSITY
5K CPS
FULL SCALE
HOLE
N-N NEUTRON
1K CPS
FULL SCALE
CALIPER
1 IN/DIV
1007

0'
50'
68'
-FLUID LEV
-CASING-
NATURAL GAMMA
50 CPS
FULL SCALE
SPONTANEOUS
POTENTIAL
2 MV/DIV
HOLE
RESISTANC
10 Ω/DIV
1007

COLORADO WELL LOGGING, INC.

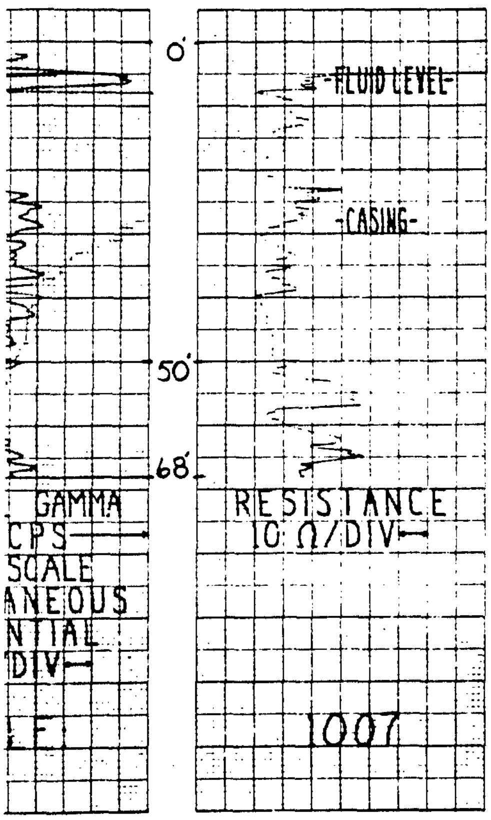
H BOUND — HOLE 1007
TECHNICAL — DATE 25 JAN 80
ADAMS — SEC 24 — TWP 2S — RGE 67W
PQ 4.8 IN
CASING THICK. 1/4 IN.
2 DAYS
BENTONITE — DRILLING CONTRACTOR CUSTOM AUGER
THRU CASING X — CORRECTION FACTORS N/A — CASING N/A — WATER N/A

2500
23 — 21
2.33 x 10
< 1 μ SEC
1 SEC
TIME ON 1055 — OFF 1115
OPERATOR KIRCHNER
WITNESS MS. BILODEAU

RESISTANCE
DEPTH FROM 68 TO 0
LOGGING SPEED FT/MIN 25
RATIO Ω/DIV 10
BIAS X0.5 250

SPONTANEOUS POTENTIAL
DEPTH FROM 68 TO 0
LOGGING SPEED FT/MIN 25
RATIO MV/DIV 2
BIAS X0.5 100

SA GEOTECHNICAL — HOLE NO 1007 — DATE 1/25/80



PENETRATION NO	GRADATION RESULTS % PASSING NO 200 WASH		1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
30-45 N=7	69.3 % PASSING												
80-95 N=14													
130-145 N=19	45 % PASSING	% PASSING →				100	97.1	87.0	52.1	20.3	9.0	5.7	4.5
180-195 N=113													
230-245 N=24 BEGAN CORING AT 245 FT													

(Column group header: GRADATION SIEVE SIZES)

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 8 OF 30

JUNE 1981

DACA45-81-R-0161

C-47 — 71-07-16

SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45-? C? — MODIFICATION NO.

$$ — THINK VALUE ENGINEERING — $$

7

COLORADO WELL LOGGING, INC.

COLOG

PROJECT	NO. 2133 RMA N. BND
HOLE	1008
COMPANY	ESA GEOTECHNICAL
DATE	6 FEB 80
STATE	COLO
COUNTY	ADAMS
METER MODEL	MT SCP 2500
PROBE NO	347
UNIT NO	24
K FACTOR	2.36 X 10-6
DEAD TIME	< 1 µSEC
TIME CONSTANT	1 SEC
TIME ON	0815
OFF	0930
OPERATOR	CARRINGTON
WITNESS	MS. BILODEAU

DRILL HOLE DATA

DEPTH DRILLED	70 FT
COLLAR ELEV	UNK
CASING THICK	3/8 IN
DEPTH LOGGED	63 FT
BIT SIZE	PQ 4.8 IN
DRILL PIPE THICK	N/A
DEPTH CASING	27 FT
TIME SINCE CIRCULATION	6 DAYS
FLUID LEVEL	6 FT
TYPE FLUID	BENTONITE
DRILLING CONTRACTOR	CUSTOM AUGER
LOGGED OPEN HOLE	X
THRU PIPE	—
THRU CASING	X
CORRECTION FACTORS PIPE	N/A
CASING	1.37
WATER	1.032

NATURAL GAMMA	INITIAL RUN
DEPTH FROM	63
TO	0
NO. OF FT	63
FULL SCALE (CPS)	50
CHART RATIO FT/IN	10
LOGGING SPEED FT/MIN	15
DIGITAL PRINTOUT	

γ-γ GAMMA	INITIAL RUN
DEPTH FROM	63
TO	0
NO. OF FT	63
FULL SCALE (CPS)	5K
BIAS	0
CHART RATIO FT/IN	10
LOGGING SPEED FT/MIN	15
DIGITAL PRINTOUT	

REMARKS

RESISTANCE	INIT
DEPTH FROM	61
TO	SURF
LOGGING SPEED FT/MIN	25
RATIO Ω/DIV	10
BIAS	327

SPONTANEOUS POTENTIAL	INIT
DEPTH FROM	61
TO	SURF
LOGGING SPEED FT/MIN	25
RATIO mV/DIV	2
BIAS mV	45

COMPANY ESA PROJECT 2133 HOLE NO 1008 DATE 2-6-80

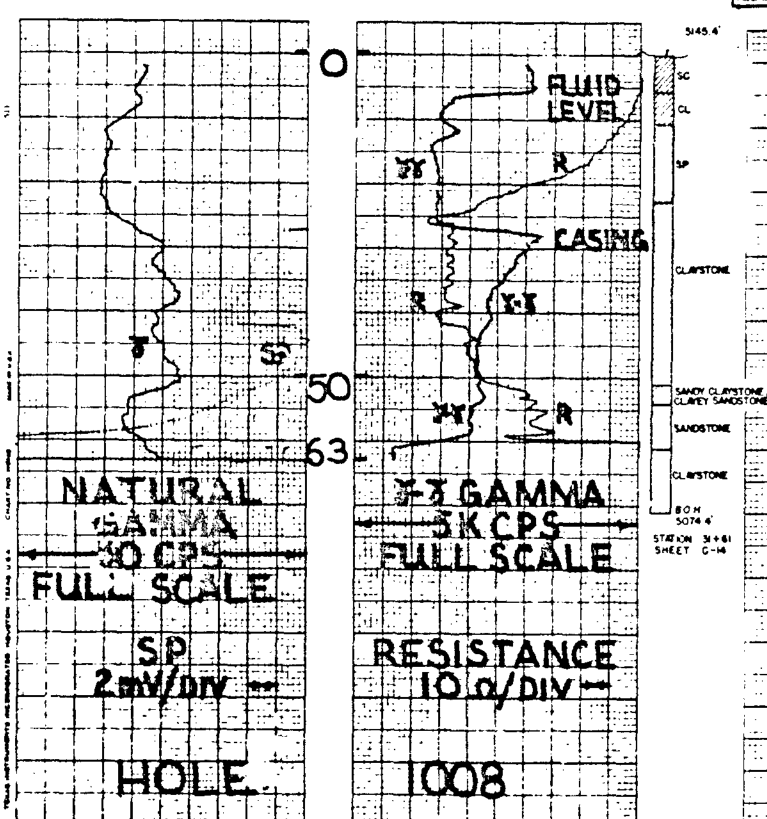
COLORADO WELL LOGGING, INC

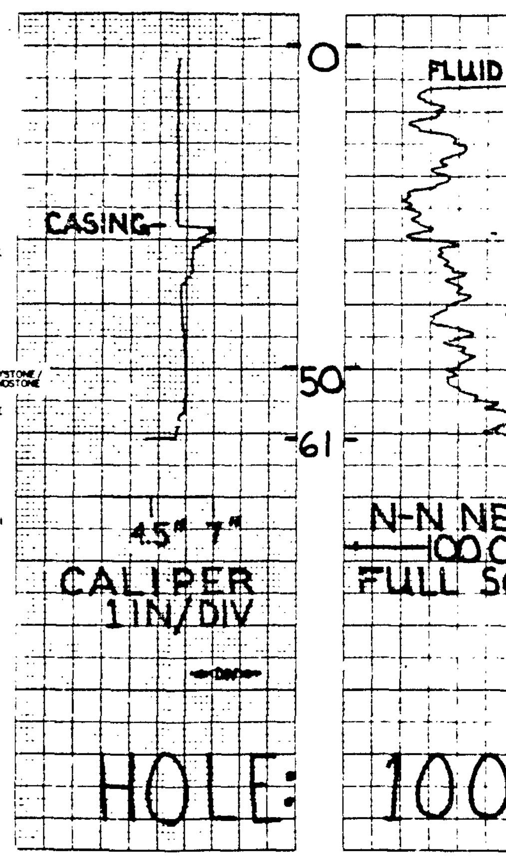
COLOG

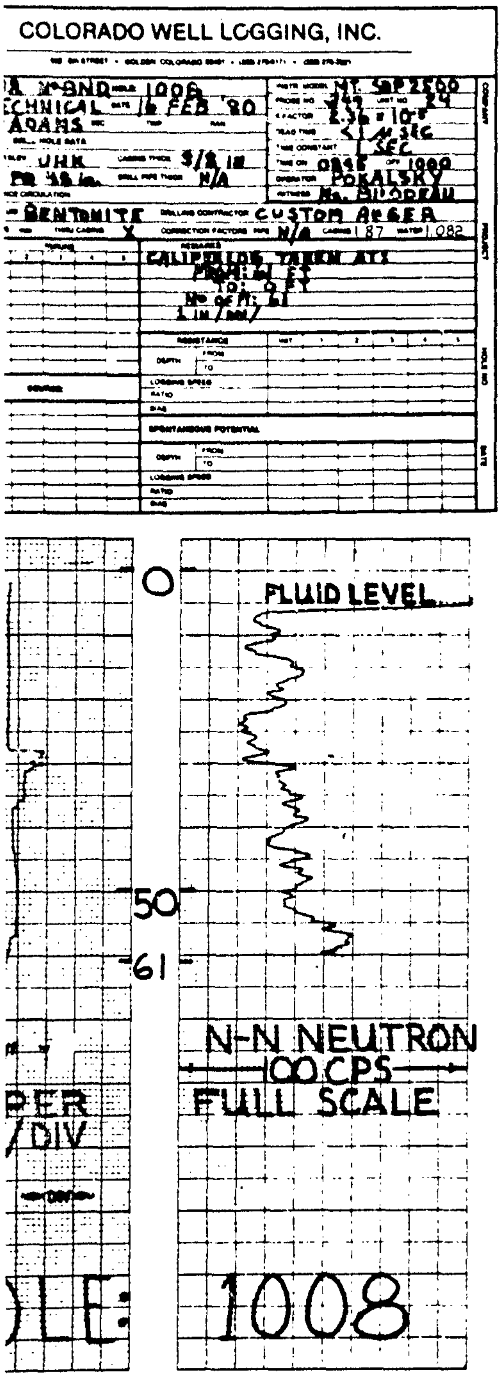
PROJECT	No. 2133 RMA N. BND
HOLE	1003
COMPANY	ESA GEOTECHNICAL
DATE	16 FEB '80
STATE	COLO
COUNTY	ADAMS
DEPTH DRILLED	61 FT.
COLLAR ELEV	UNK
CASING THICK	3/8 IN
DEPTH LOGGED	61 FT.
BIT SIZE	PQ 4.8 in.
DRILL PIPE THICK	N/A
DEPTH CASING	30 FT.
FLUID LEVEL	35 FT
TYPE FLUID	BENTONITE
DRILLING CONTRACTOR	CUSTOM A
LOGGED OPEN HOLE	X
THRU CASING	X
CORRECTION FACTORS PIPE	N/A

REMARKS: CALIPER LOG TAKEN — FROM 61 FT TO 0 FT; No OF FT 61; 1 in/DIV

N-N NEUTRON	
DEPTH FROM	60
TO	0
NO. OF FT	60
FULL SCALE (CPS)	100
BIAS	0
CHART RATIO FT/IN	10
LOGGING SPEED FT/MIN	15







PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH		1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.0-4.5 N=5													
8.0-9.5 N=4	67.4% PASSING												
13.0-14.5 N=23													
18.0-19.5 N=11	7.8 % PASSING	% PASSING ——			100	99.0	97.5	93.9	79.1	43.7	17.9	10.3	8.1
23.0-24.4 N=176+/.1"													
28.0-29.5 N=33 BEGAN CORING AT 29.5 FT													

(GRADATION SIEVE SIZES: 1" through #200)

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

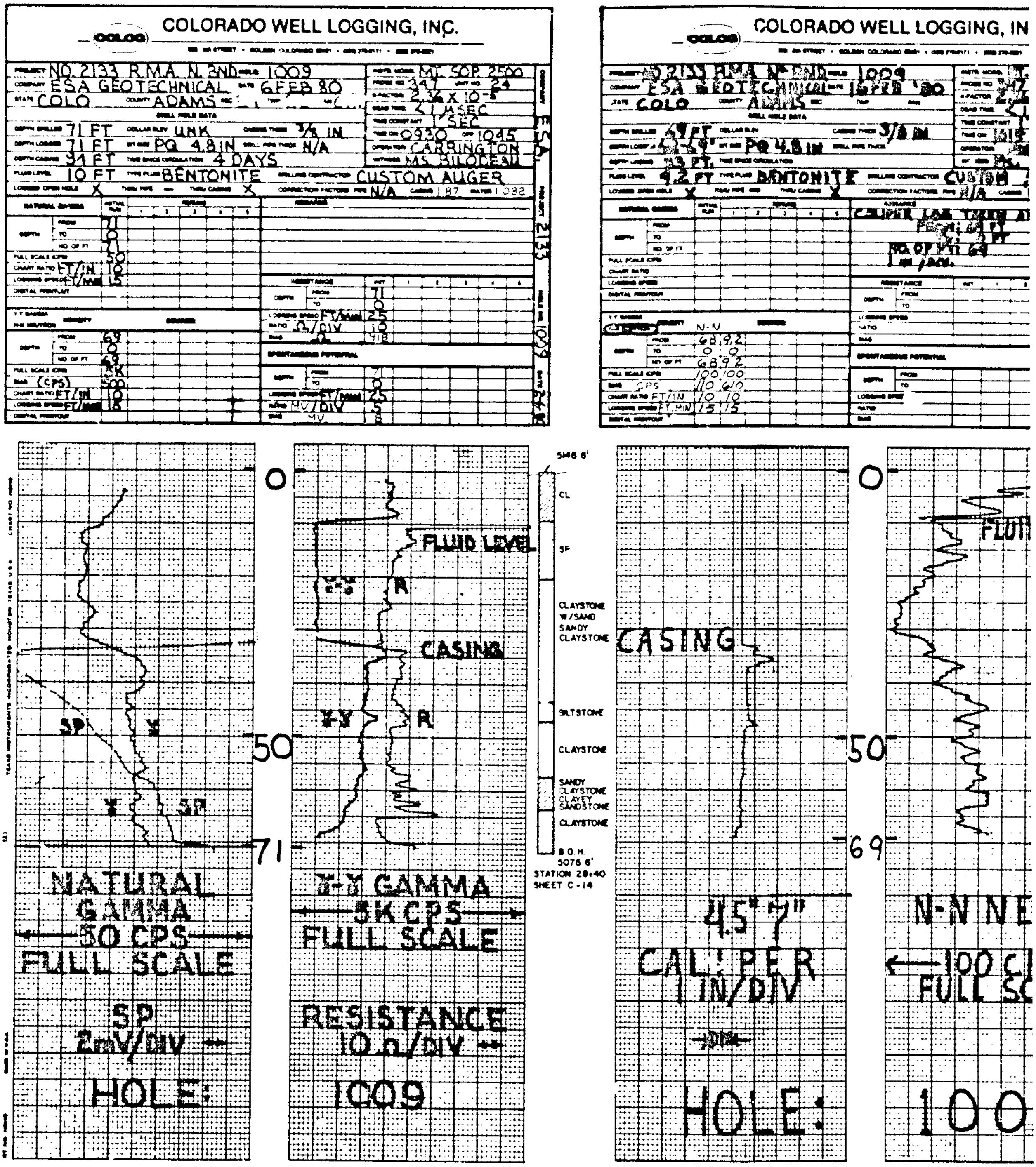
ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 9 OF 30

JUNE 1980

THIS PLAN ACCOMPANIES CONTRACT No. DACA 45-7 CO

71-07-16

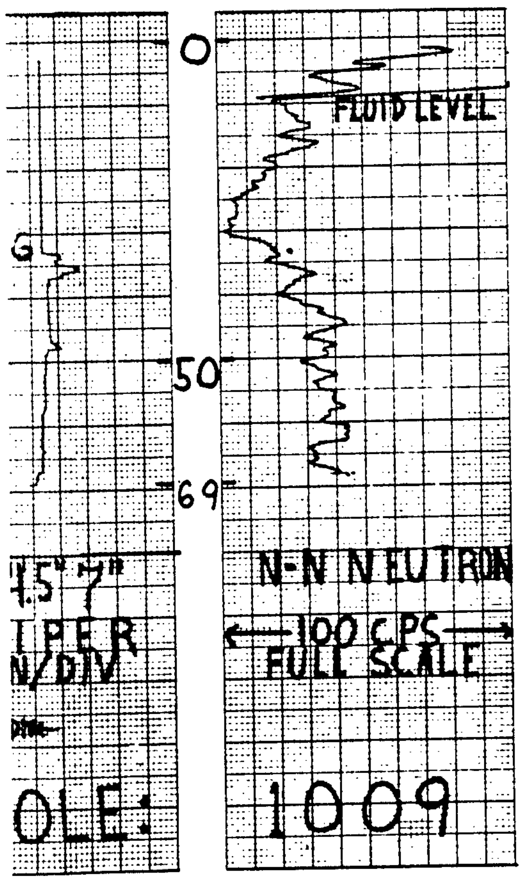

COLORADO WELL LOGGING, INC.
NO 2133 RMA N 3ND
1009
ESA GEOTECHNICAL
6FEB80
COLO
ADAMS
71 FT
UNK
3/8 IN
PQ 4.8 IN
N/A
31 FT
4 DAYS
10 FT
BENTONITE
CUSTOM AUGER
CARRINGTON
MS. BILODEAU
FLUID LEVEL
CASING
CL
SF
CLAYSTONE W/SAND
SANDY CLAYSTONE
SILTSTONE
CLAYSTONE
SANDY CLAYSTONE
CLAYEY SANDSTONE
CLAYSTONE
B.O.H. 5076.6'
STATION 28+40
SHEET C-14
NATURAL GAMMA
50 CPS FULL SCALE
SP 2mV/DIV
HOLE:
Y-Y GAMMA
5K CPS FULL SCALE
RESISTANCE 10 Ω/DIV
1C09
4.5" 7"
CALIPER 1 IN/DIV
HOLE:
N-N NE
100 C
FULL SC
100

COLORADO WELL LOGGING, INC.

HOLE	1009
DATE	16 FEB '80
COUNTY	ADAMS
CASING THICK	3/8 IN
BIT SIZE	PQ 4.8 IN
TYPE FLUID	BENTONITE
DRILLING CONTRACTOR	CUSTOM AUGER
CORRECTION FACTORS	N/A
CASING	1.67
WATER	1.082

REMARKS: CALIPER LOG TAKEN AT: FROM: 4 FT. TO 5 FT. NO. OF PTS 64 1 IN./ADM.

9.2
0
9.2
100
60
10
5



PENETRATION NO.		GRADATION RESULTS % PASSING NO. 200 WASH		1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
4.5-6.0	N=4	49.6% PASSING												
9.5-11.0	N=5													
14.5-16.0	N=21	14.8% PASSING	% PASSING			100	96.3	89.6	87.8	73.1	49.4	25.8	17.4	15.4
19.5-21.0	N=24													
24.5-25.5	N=127/12"													
29.5-31.0	N=67													

BEGAN CORING AT 35.0' FT.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U.S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 10 OF 30

JUNE 1980

71-07-16

SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO

COLORADO WELL LOGGING, INC.

PROJECT NO. 2133 R.M.A. N. BNDY HOLE 1010
COMPANY ESA GEOTECHNICAL DATE 6 FEB 80
STATE COLO COUNTY ADAMS TWP 2
METER MODEL MT SCP 2500
PROBE NO 347 UNIT NO 29
K-FACTOR 2.36 X 10⁻⁸
DEAD TIME < 1 μSEC
TIME CONSTANT 1 SEC
DRILL HOLE DATA
DEPTH DRILLED 70 FT COLLAR ELEV UNK. CASING THICK 3/8 IN
DEPTH LOGGED 67 FT BIT SIZE PQ 4.8 IN DRILL PIPE THICK N/A
DEPTH CASING 33 FT TIME SINCE CIRCULATION 2 DAYS
TIME ON 1045 OFF 1130
OPERATOR CARRINGTON
WITNESS MS. BILODEAU
FLUID LEVEL 8 FT TYPE FLUID BENTONITE DRILLING CONTRACTOR CUSTOM AUGER
LOGGED OPEN HOLE X THRU PIPE — THRU CASING X CORRECTION FACTORS PIPE N/A CASING 1.37 WATER 1.032

NATURAL GAMMA		INITIAL RUN
DEPTH	FROM	67
	TO	0
	NO OF FT	67
FULL SCALE (CPS)		30
CHART RATIO FT/IN		10
LOGGING SPEED FT/MIN		15
DIGITAL PRINTOUT		

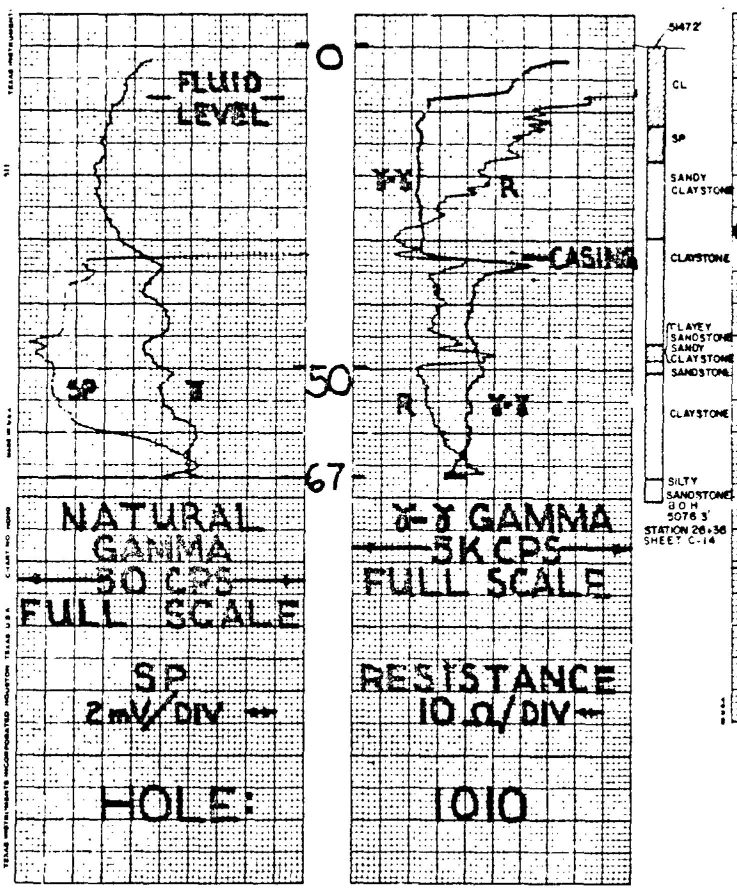
γ-γ GAMMA / N-N NEUTRON		
DEPTH	FROM	67
	TO	0
	NO OF FT	67
FULL SCALE (CPS)		5K
BIAS		0
CHART RATIO FT/IN		10
LOGGING SPEED FT/MIN		15
DIGITAL PRINTOUT		

REMARKS

RESISTANCE		INIT
DEPTH	FROM	67
	TO	0
LOGGING SPEED FT/MIN		25
RATIO Ω/DIV		10
BIAS		322

SPONTANEOUS POTENTIAL		
DEPTH	FROM	67
	TO	0
LOGGING SPEED FT/MIN		25
RATIO mV/DIV		2
BIAS mV		34

COMPANY ESA PROJECT 2133 HOLE NO 1010

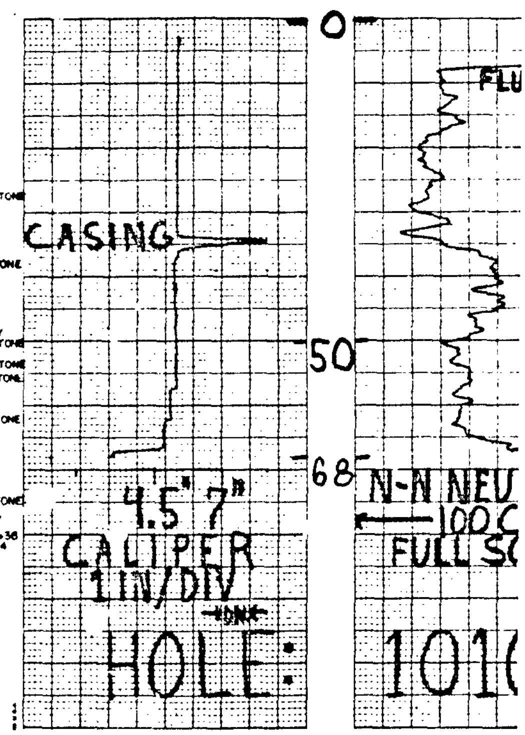


COLORADO WELL LOGGING, IN

PROJECT NO. 2133 RMA N. BND. HOLE 1010
COMPANY ESA GEOTECHNICAL DATE 6 FEB '80
STATE COLO COUNTY ADAMS
DEPTH DRILLED 69 FT COLLAR ELEV UNK CASING THICK 3/8 IN
DEPTH LOGGED 68 FT BIT SIZE PQ 4.8 IN DRILL PIPE THICK N/A
DEPTH CASING 33 FT
FLUID LEVEL 8 FT TYPE FLUID BENTONITE DRILLING CONTRACTOR CUSTOM
LOGGED OPEN HOLE X THRU PIPE — THRU CASING X CORRECTION FACTORS PIPE N/A

REMARKS
CALIPER DATA:
FROM: 68 FT
TO: 0 FT
No of FT 68
1 in/DIV.

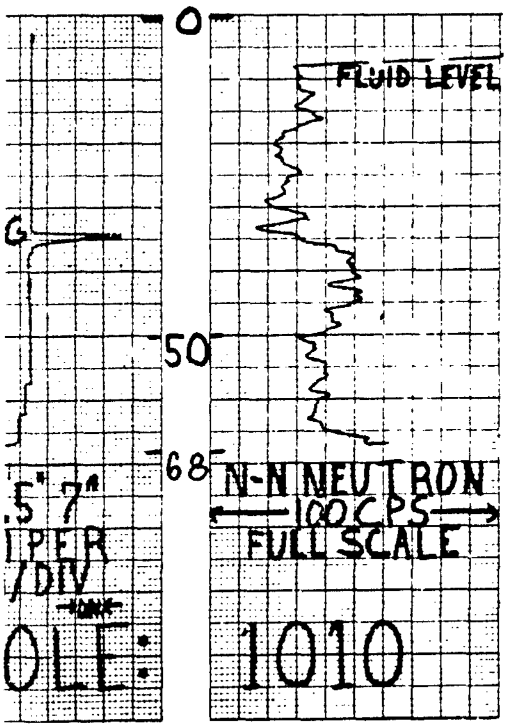
γ-γ GAMMA / N-N NEUTRON		N-N
DEPTH	FROM	67
	TO	0
	NO OF FT	67
FULL SCALE (CPS)		100
BIAS		0
CHART RATIO FT/IN		10
LOGGING SPEED FT/MIN		15



COLORADO WELL LOGGING, INC.

RMA N. BND. HOLE 1010
TECHNICAL DATE 11 FEB '80
COUNTY ADAMS
COLLAR ELEV UNK — CASING THICK 3/8 IN
BIT SIZE PQ 4.8 IN — DRILL PIPE THICK N/A
TYPE FLUID BENTONITE — DRILLING CONTRACTOR CUSTOM AUGER
THRU CASING X — CORRECTION FACTORS PIPE N/A CASING 1.87 WATER 1.082
PROBE MODEL N.SNP. 2500
PROBE NO 247 UNIT NO 34
K FACTOR 2.56 × 10⁻³
DEAD TIME < 1 µSEC
TIME CONSTANT 1 SEC
TIME ON 1100 / 1200
OPERATOR POKALSKY
WITNESS MS. BILODEAU

REMARKS: CALIPER DATA: FROM: 68 FT TO: 0 FT



PENETRATION NO.	GRADATION RESULTS % PASSING NO 200 WASH		1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
4.0-5.5 N=5	52.6 % PASSING												
9.0-10.5 N=5	35.7 % PASSING												
14.0-15.5 N=13	13.5 % PASSING	% PASSING				100	99.2	97.5	84.4	50.6	27.0	18.4	14.4
19.0-20.5 N=41													
24.0-25.5 N=56													
29.0-30.5 N=58													

BEGAN CORING AT 35.0 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

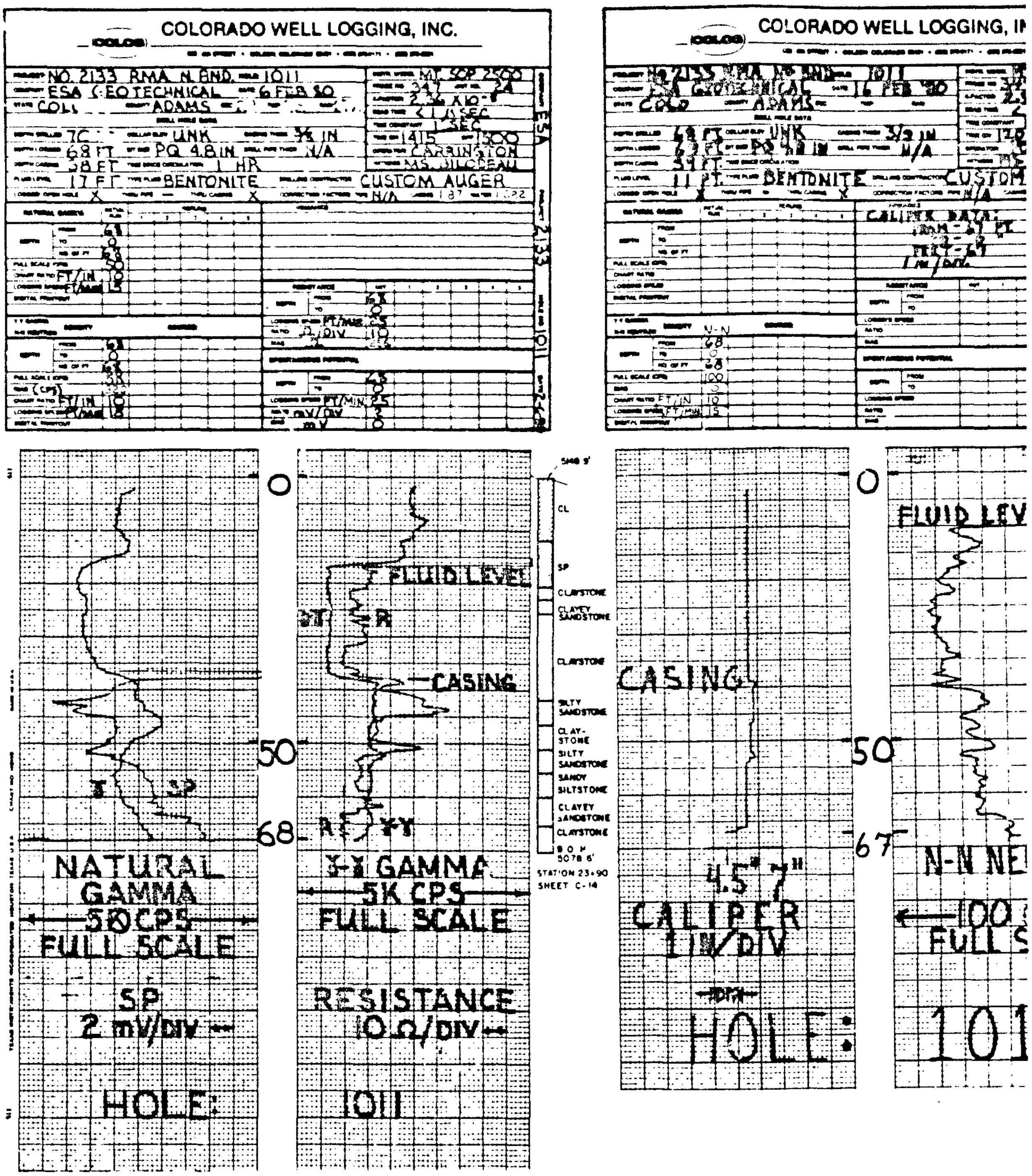
ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

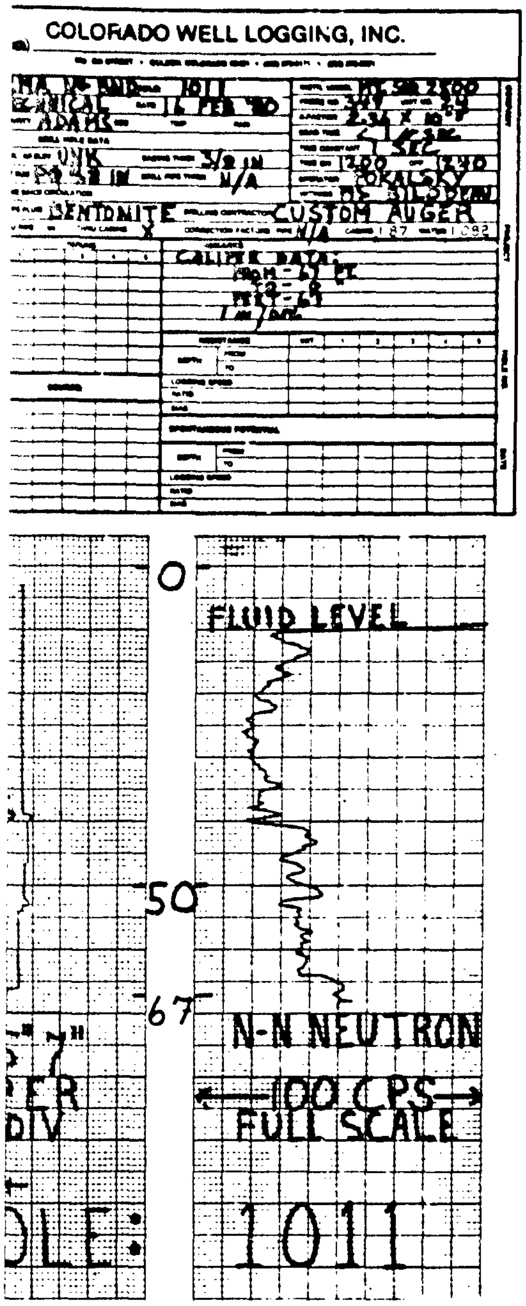
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 11 OF 30

JUNE 1980

71-07-1S

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45-7 CO — MODIFICATION NO.


COLORADO WELL LOGGING, INC.
NO. 2133 RMA N BND. 1011
ESA GEOTECHNICAL 6 FEB 80
COLO ADAMS
68 FT PQ 4.8 IN N/A
58 FT 1 HR
17 FT BENTONITE CUSTOM AUGER
MS. JILCREAU
FLUID LEVEL
CASING
NATURAL GAMMA
50 CPS FULL SCALE
SP
2 mV/DIV
HOLE:
γ-γ GAMMA
5K CPS FULL SCALE
RESISTANCE
10 Ω/DIV
1011
CL
SP
CLAYSTONE
CLAYEY SANDSTONE
SILTY SANDSTONE
SANDY SILTSTONE
STATION 23+90
SHEET C-14
COLORADO WELL LOGGING, IN
CALIPER DATA
4.5" 7"
CALIPER
1 IN/DIV
N-N NE
FULL S
101



PENETRATION NO	GRADATION RESULTS % PASSING NO. 200 WASH		1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.0-4.5 N=11													
8.0-9.5 N=4	61.5% PASSING												
13.0-14.5 N=48	23.1% PASSING	% PASSING					100	99.9	96.4	81.6	54.2	33.4	24.4
18.0-19.5 N=13													
23.0-23.9 N=140/11"													
28.0-29.5 N=48													
33.0-34.5 N=54													
38.0-39.5 N=115													

BEGAN CORING AT 40.7 FT.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

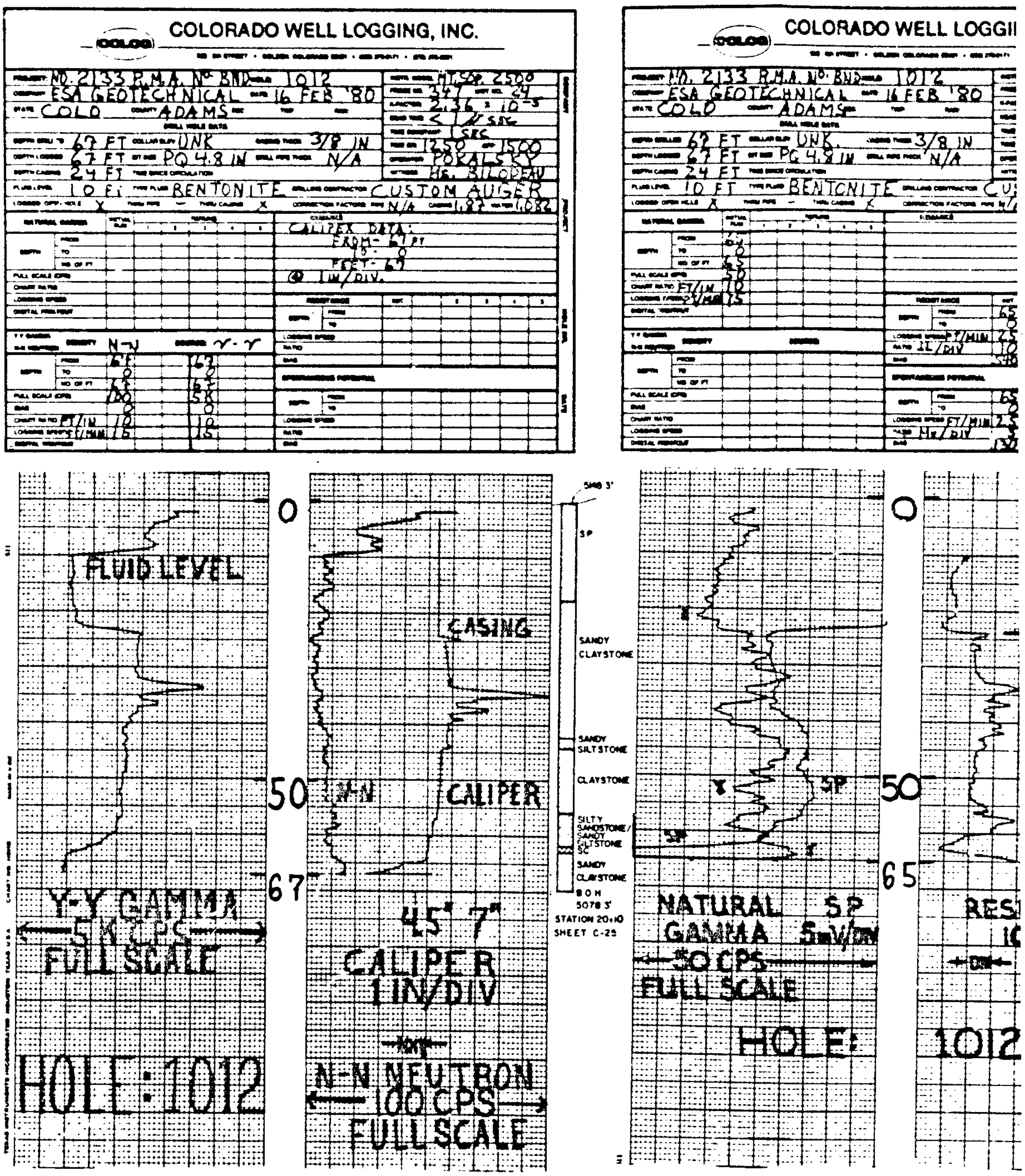
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 12 OF 30

JUNE 1980

DACA45-80-R-0161

C-81 71-07-16

DACA 45-7 CO


COLORADO WELL LOGGING, INC.
NO. 2133 R.M.A. Nº BND
1012
ESA GEOTECHNICAL
16 FEB '80
COLO
ADAMS
67 FT
UNK
3/8 IN
PQ 4.8 IN
N/A
24 FT
10 FT
BENTONITE
CUSTOM AUGER
CALIPER DATA:
N-N
γ-γ
COLORADO WELL LOGGI
0
FLUID LEVEL
CASING
50
N-N
CALIPER
67
Y-Y GAMMA
5K CPS
FULL SCALE
45" 7"
CALIPER
1 IN/DIV
HOLE: 1012
N-N NEUTRON
100 CPS
FULL SCALE
SP
SANDY CLAYSTONE
SANDY SILTSTONE
CLAYSTONE
SILTY SANDSTONE/ SANDY SILTSTONE
SANDY CLAYSTONE
STATION 20+10
SHEET C-25
NATURAL GAMMA
50 CPS
FULL SCALE
SP
5mV/DIV
HOLE:
65
RES
1012

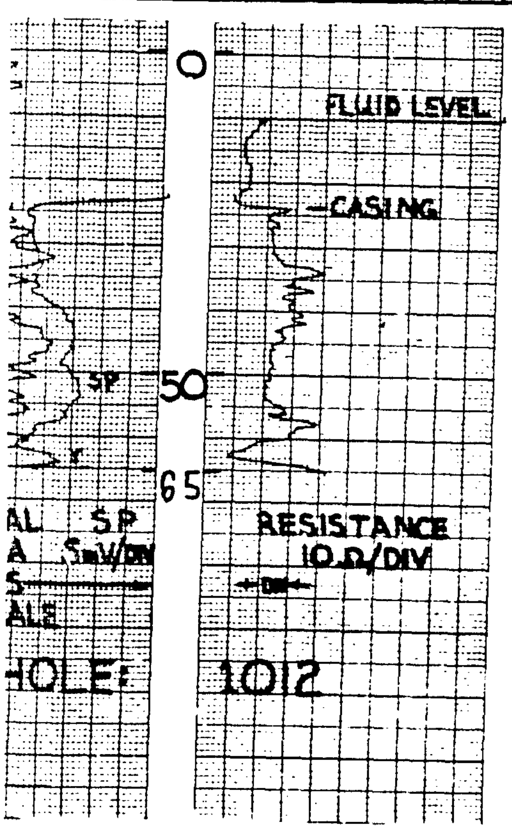
COLORADO WELL LOGGING, INC.

R.M.A. No. RND 1012
TECHNICAL 16 FEB '80
ADAMS
UNK. 3/8 IN
Pr 4.9 IN N/A
BENTONITE CUSTOM AUGER
6 N/A .97 .092

HL 50R2500
343 24
2.36 x 10⁻⁸
< 1 SEC.
1 SEC.
12:30 1500
POKALSKY
MS. BILODEAU

65	
0	
FT/MIN	25
Ω/DIV	10
	530

65	
0	
FT/MIN	25
mV/DIV	5
	130



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	GRADATION SIEVE SIZES 1" 3/4" 1/2" 3/8" #4 #10 #20 #40 #60 #100 #200
3.0-4.5 N=10		
8.0-9.5 N=11		
13.0-14.5 N=22		
18.0-19.5 N=72	NO GRADATION TEST WAS RUN ON ANY SAMPLE FROM THIS BORING	
23.0-24.5 N=43		
BEGAN CORING AT 26.0 FT.		

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

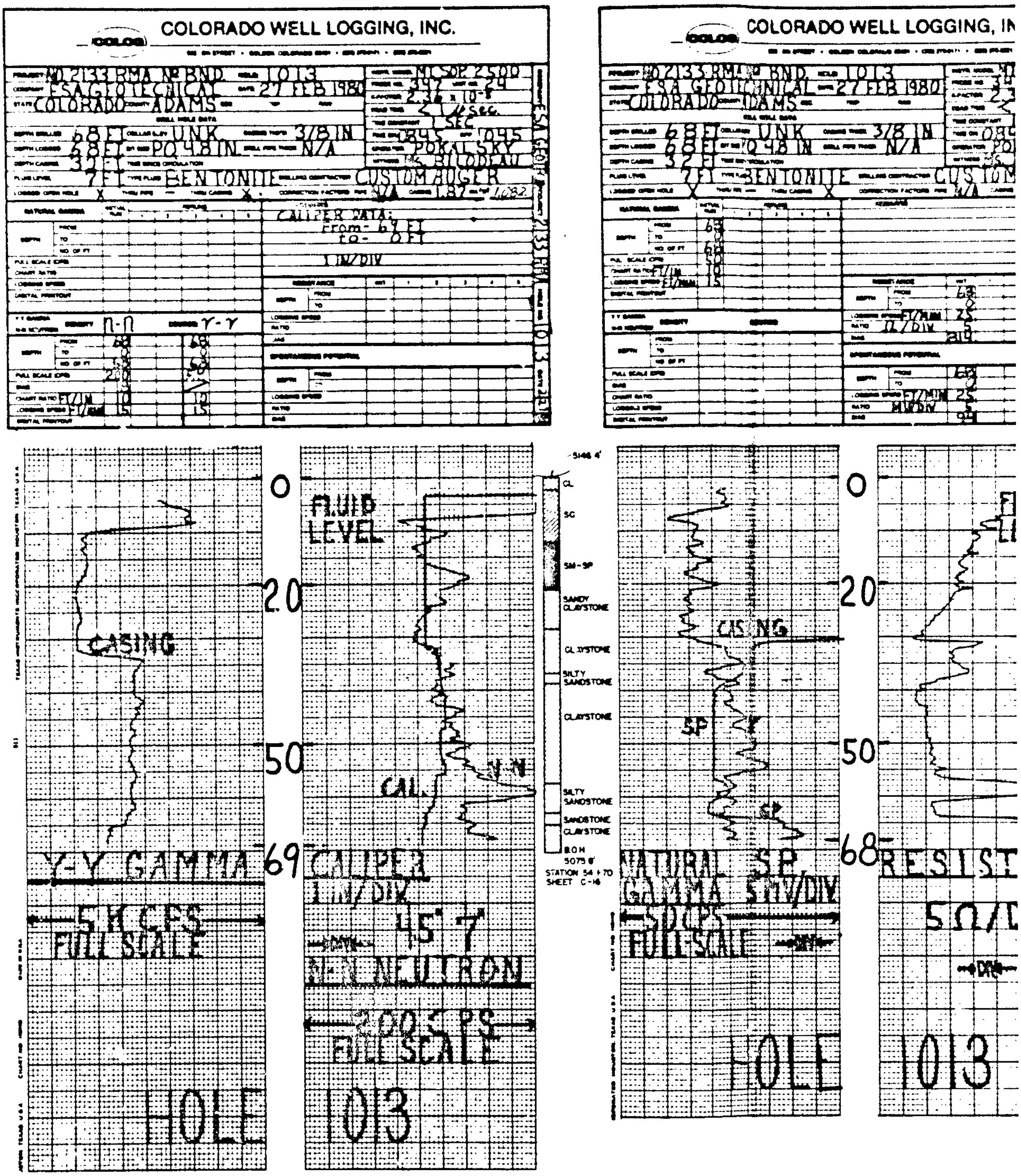
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 13 OF 30

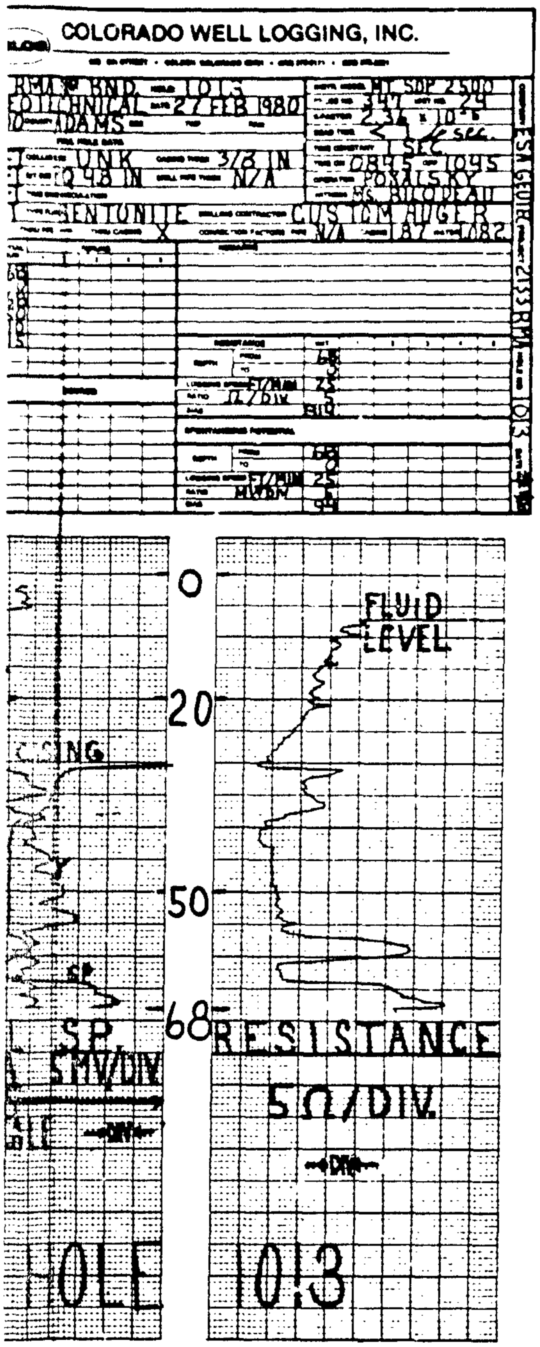
JUNE 1980
DACA45 80 R 0161
71-07-16

SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 C0

$$ – THINK VALUE ENGINEERING – $$


COLORADO WELL LOGGING, INC.
COLORADO
ADAMS
BENTONITE
CUSTOM AUGER
CALIPER DATA:
From 67 FT
to 0 FT
1 IN/DIV
5146.4'
0
20
50
69
68
FLUID LEVEL
CASING
CAL.
N-N
SP
CL
SC
SM-SP
SANDY CLAYSTONE
CLAYSTONE
SILTY SANDSTONE
CLAYSTONE
SILTY SANDSTONE
SANDSTONE
CLAYSTONE
BOH 5075.8'
STATION 54+70
SHEET C-16
Y-Y GAMMA
5K CPS FULL SCALE
CALIPER 1 IN/DIV
N-N NEUTRON
200 CPS FULL SCALE
NATURAL GAMMA
S.P. 5 MV/DIV
50 CPS FULL SCALE
HOLE 1013
HOLE 1013



PENETRATION NO.		GRADATION RESULTS % PASSING NO. 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
30-45	N=6												
80-95	N=4	43.3 % PASSING											
130-145	N=7												
180-195	N=10	29.6 % PASSING											
230-245	N=17												
280-290	N=50												

BEGAN CORING AT 290 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 14 OF 30

JUNE 1980

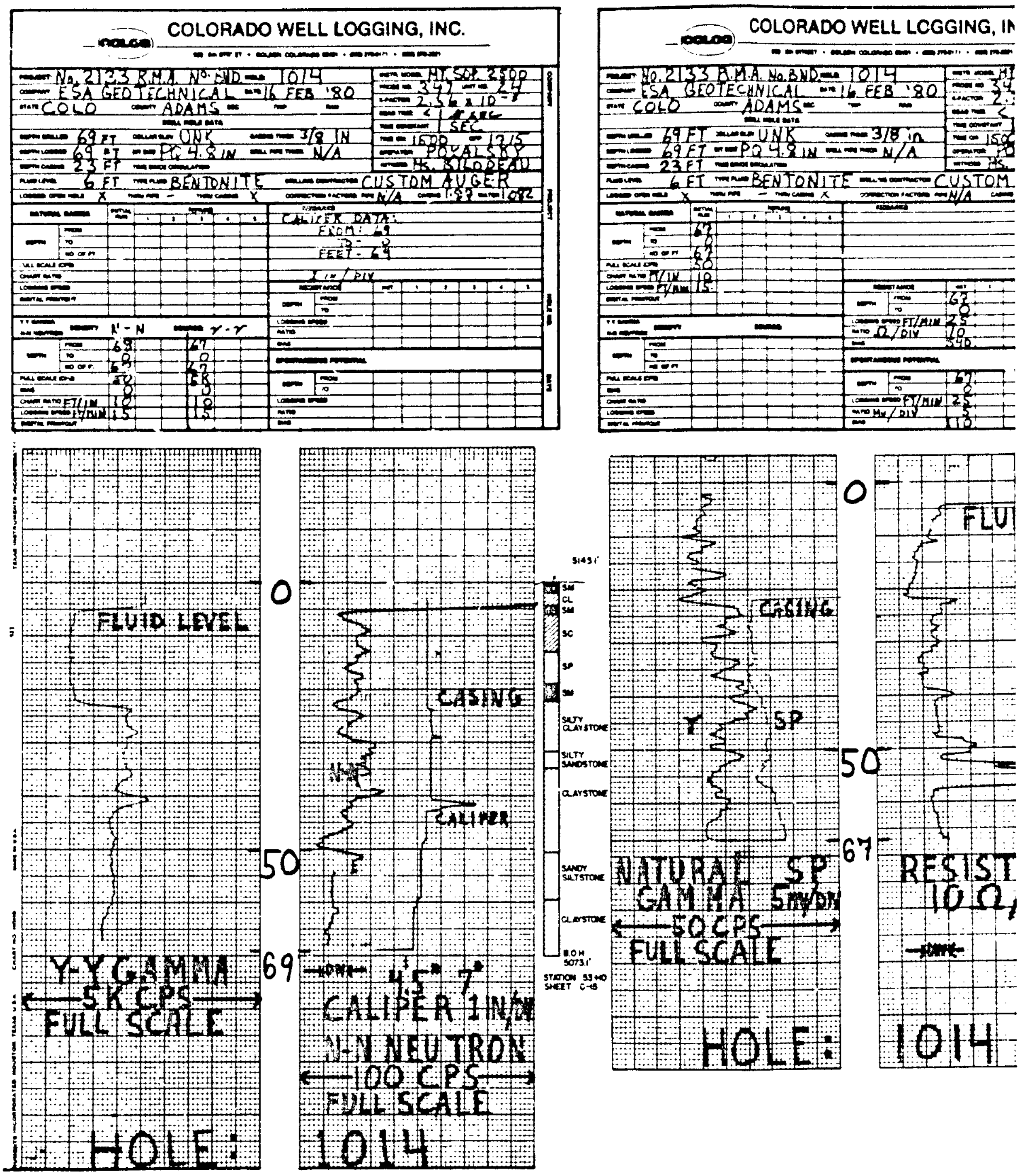
DACA45-80-R-0161

71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 C0 MODIFICATION NO.

THINK VALUE ENGINEERING

PLATE 40


COLORADO WELL LOGGING, INC.
No. 2133 B.M.A. No. BND 1014
ESA GEOTECHNICAL 16 FEB '80
COLO ADAMS
69 FT UNK 3/8 IN
69 FT PQ 4.8 IN N/A
23 FT
6 FT BENTONITE CUSTOM AUGER
CALIPER DATA:
FROM: 69
TO: 0
FEET: 69
1 IN / DIV
N-N Y-Y
FLUID LEVEL
CASING
CALIPER
Y-Y GAMMA
5K CPS
FULL SCALE
HOLE:
CALIPER 1 IN/DIV
N-N NEUTRON
100 CPS
FULL SCALE
1014
SM
CL
SC
SP
SILTY CLAYSTONE
SILTY SANDSTONE
CLAYSTONE
SANDY SILTSTONE
STATION 53+40
SHEET C-18
COLORADO WELL LOGGING, IN
No. 2133 B.M.A. No. BND 1014
ESA GEOTECHNICAL 16 FEB '80
COLO ADAMS
69 FT UNK 3/8 in
69 FT PQ 4.8 IN N/A
23 FT
6 FT BENTONITE CUSTOM
CASING
SP
NATURAL GAMMA
SP 5mV/DIV
50 CPS
FULL SCALE
HOLE:
RESIST
FLU
1014

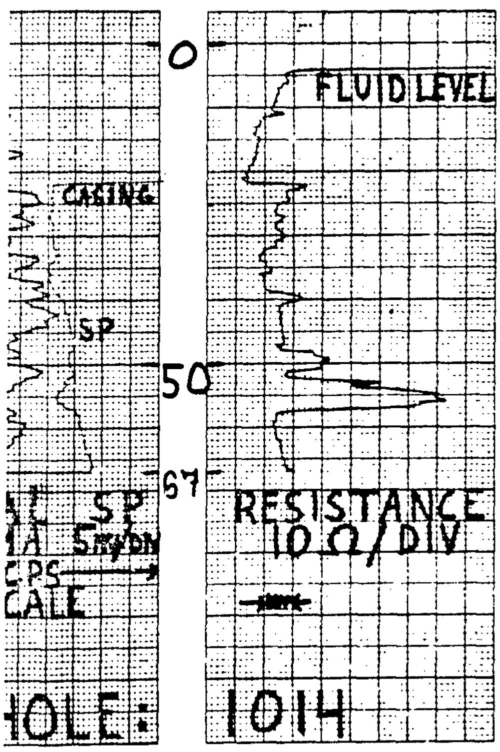
COLORADO WELL LOGGING, INC.

R.M.A. No. BND 1014
TECHNICAL — 16 FEB '80
ADAMS
UNK — 3/8 in.
PQ 4.9 IN — N/A
BENTONITE — CUSTOM AUGER
X — N/A — 1.97 — 1082

HT SDP 2500
347 — 24
2.36 x 10⁻⁵
< 1/4 SEC
1 SEC
1500 — 1715
POKALSKY
MS. BILODEAU

Depth from	67
to	0
Logging speed FT/MIN	25
Ratio Ω/DIV	10
	540

Depth from	67
to	0
Logging speed FT/MIN	25
Ratio Mv/DIV	5
	110



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.5-5.0 N=3	72.1% PASSING											
8.5-10.0 N=9												
13.5-15.0 N=11												
18.5-20.0 N=6	35.4% PASSING											
23.5-25.0 N=32 BEGAN CORING AT 25.0 FT.												

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION GEOPHYSICAL BORING LOGS SHEET 15 OF 30

JUNE 1980

DACA45-80-R-161

71-07-16

C-14

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 C0 MODIFICATION NO.

SAFETY PAYS

$$ — THINK VALUE ENGINEERING — $$

2

1

COLORADO WELL LOGGING, INC.

COLOG

PROJECT NO 2133 RMA Nº BND HOLE 1015
COMPANY ESA GEOTECHNICAL DATE 27 FEB 1980
STATE COLORADO COUNTY ADAMS

WELL HOLE DATA

DEPTH DRILLED 70 FT COLLAR ELEV UNK. CASING THICK 3/8 IN.
DEPTH LOGGED 70 FT BIT SIZE PQ 4.8 IN DRILL PIPE THICK N/A
DEPTH CASING 23 FT
FLUID LEVEL 5 FT TYPE FLUID BENTONITE DRILLING CONTRACTOR CUSTOM AUGER
LOGGED OPEN HOLE X THRU PIPE — THRU CASING X CORRECTION FACTORS PIPE N/A CASING 1.87 WATER 1.082

MI SDP 2500 · 347 · 24 · 2.36 x 10⁻³ · <1/4 SEC. · 1 SEC · TIME ON 1045 OFF 1230 · OPERATOR POKALSKY · WITNESS K. BIDODEAU

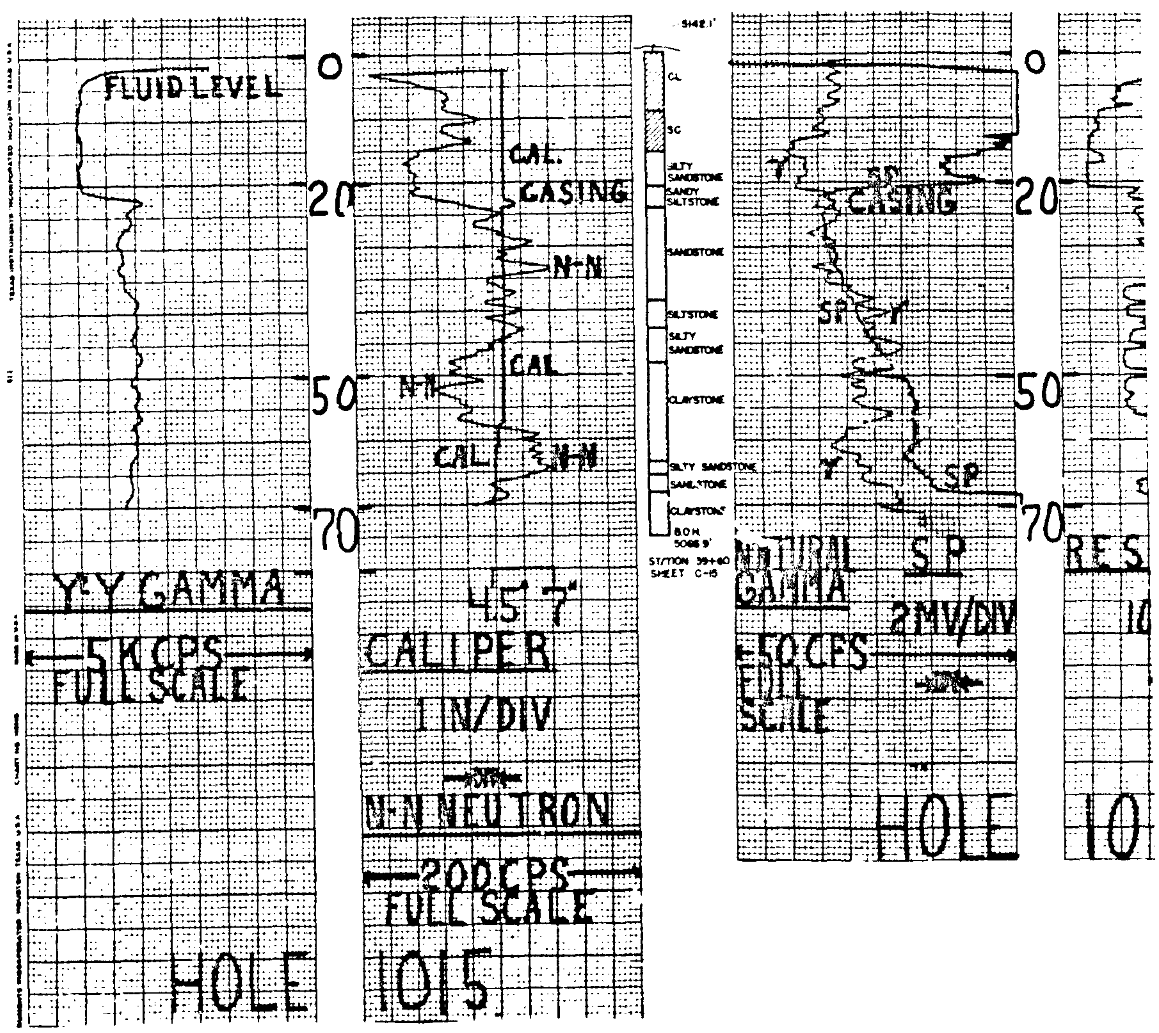
REMARKS: CALIPER DATA:
FROM - 70 FT 1 IN/DIV
TO - 0 FT

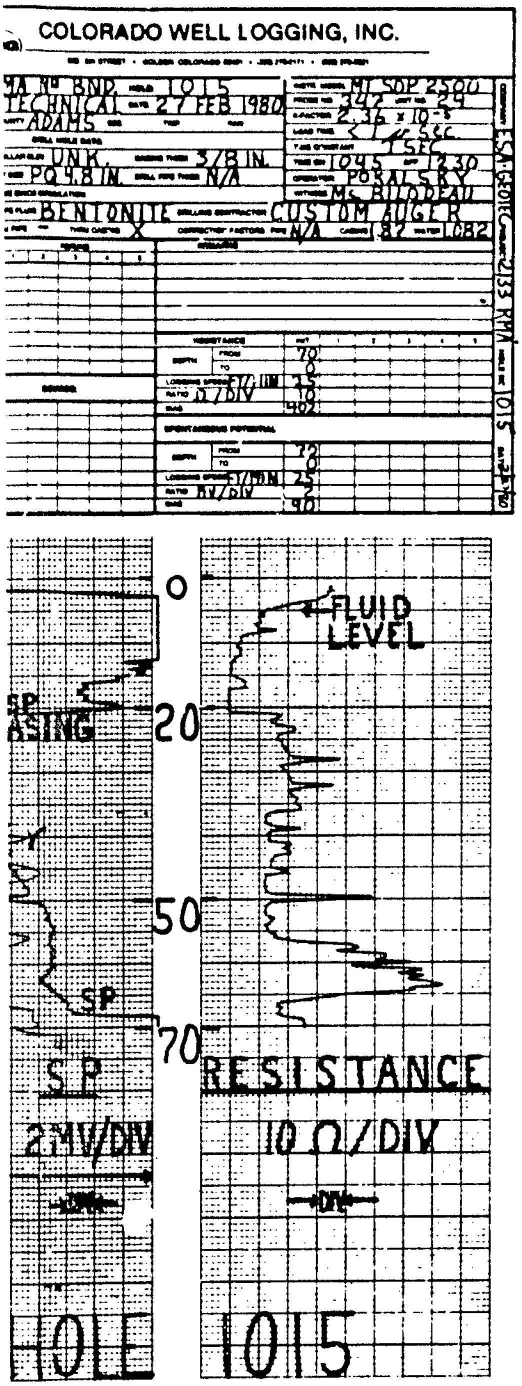
	N-N	Y-Y
DEPTH FROM	70	70
TO	0	0
NO OF FT	70	70
FULL SCALE (CPS)	200	5K
BIAS	1.3	
CHART RATIO 5 FT/IN	10	10
LOGGING SPEED 5 FT/MIN	15	15

ESA GEOTECHNICAL · 2133 RMA · 1015 · 2/27/80

COLORADO WELL LOG[GING, INC.]

PROJECT NO 2133 RMA Nº BND HOLE 1015
COMPANY ESA GEOTECHNICAL DATE 27 FEB 1980
STATE COLORADO COUNTY ADAMS
DEPTH DRILLED 70 FT COLLAR ELEV UNK. CASING THICK 3/8 IN.
DEPTH LOGGED 70 FT BIT SIZE PQ 4.8 IN DRILL PIPE THICK N/A
DEPTH CASING 23 FT
FLUID LEVEL 5 FT TYPE FLUID BENTONITE
NATURAL GAMMA DEPTH FROM 70 TO 0 NO OF FT 70 · CHART RATIO 5 FT/IN 10 · LOGGING SPEED 5 FT/MIN 15
RESISTANCE LOGGING SPEED 5 FT/MIN RATIO 0.7/DIV
SPONTANEOUS POTENTIAL LOGGING SPEED 5 FT/MIN RATIO MV/DIV





PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH		GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	4	10	20	40	60	100	200
4.5-6.0 N=4	34.2% PASSING												
9.5-11.0 N=19													
14.5-16.0 N=76	16.7% PASSING	% PASSING			100	98.3	98.6	89.2	64.4	41.9	29.9	21.8	17.2
19.5-21.0 N=101													

BEGAN CORING AT 24.0 FT.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPD

REVISIONS

PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

GEOPHYSICAL BORING LOGS SHEET 16 OF 30

DATE: JUNE 196_

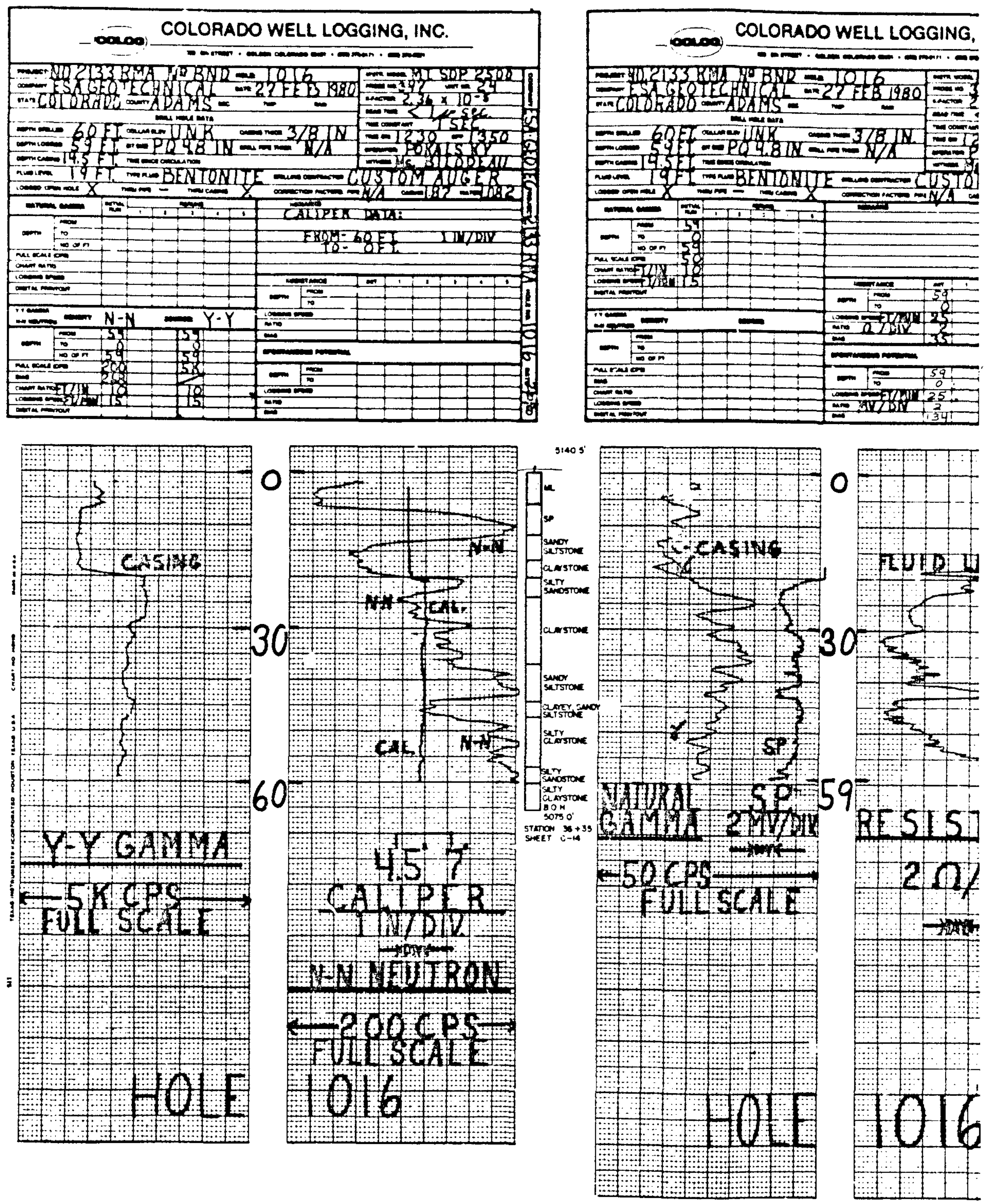
SPEC. NO. DACA45-0 R-161

71-07-16

C-58

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICATION NO.

$$ – THINK VALUE ENGINEERING – $$


COLORADO WELL LOGGING, INC.
ND 2133 RMA Nº BND
1016
ESA GEOTECHNICAL
27 FEB 1980
COLORADO
ADAMS
60 FT
UNK
3/8 IN
59 FT
PQ 4.8 IN
N/A
14.5 FT
19 FT
BENTONITE
CUSTOM AUGER
CALIPER DATA:
FROM- 60 FT
TO- 0 FT
1 IN/DIV
N-N
Y-Y
CASING
N-N
CAL.
0
30
60
Y-Y GAMMA
5K CPS
FULL SCALE
4.5
7
CALIPER
1 IN/DIV
N-N NEUTRON
200 CPS
FULL SCALE
HOLE 1016
5140.5'
ML
SP
SANDY SILTSTONE
CLAYSTONE
SILTY SANDSTONE
CLAYSTONE
SANDY SILTSTONE
CLAYEY SANDY SILTSTONE
SILTY CLAYSTONE
SILTY SANDSTONE
SILTY CLAYSTONE
B O H
5075.0'
STATION 36+35
SHEET C-14
CASING
SP
59
NATURAL GAMMA
50 CPS
FULL SCALE
SP
2 MV/DIV
FLUID
RESIST
HOLE 1016

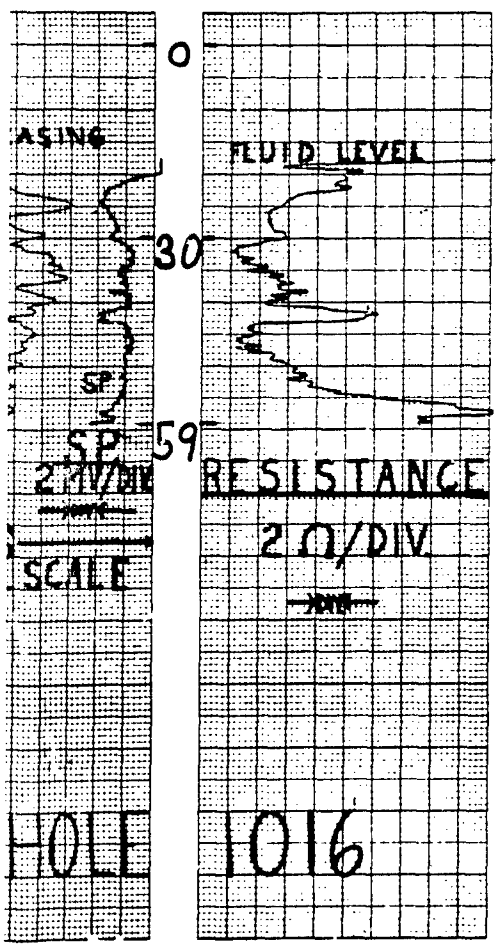
COLORADO WELL LOGGING, INC.

BNP	1016		NLSOP 2500
TECHNICAL	27 FEB 1980		342	24
ADAMS			2.36 X 10^{-3}
			< 1 μ SEC
UNK	3/8 IN.		1 SEC
PQ 4.8 IN	N/A		1230	1350
			POKATSKY
			BILODEAU
BENTONITE	CUSTOM AUGER		
X	N/A	RY	1082

DEPTH FROM	59
TO	0
LOGGING SPEED FT/MIN	25
RATIO Ω/DIV	2
	35

DEPTH FROM	59
TO	0
LOGGING SPEED FT/MIN	25
RATIO MV/DIV	2
	134

ESA GEOTEC · 133 RMA · 1016



PENETRATION NO		GRADATION RESULTS % PASSING NO. 200 WASH		GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
35-5	N=60													
85-100	N=34	94% PASSING	% PASSING			100	996	971	887	673	391	221	14.1	10.6
35-150	N=28													

BEGAN CORING AT 5.5 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

GEOPHYSICAL BORING LOGS SHEET 17 OF 30

JUNE 1980

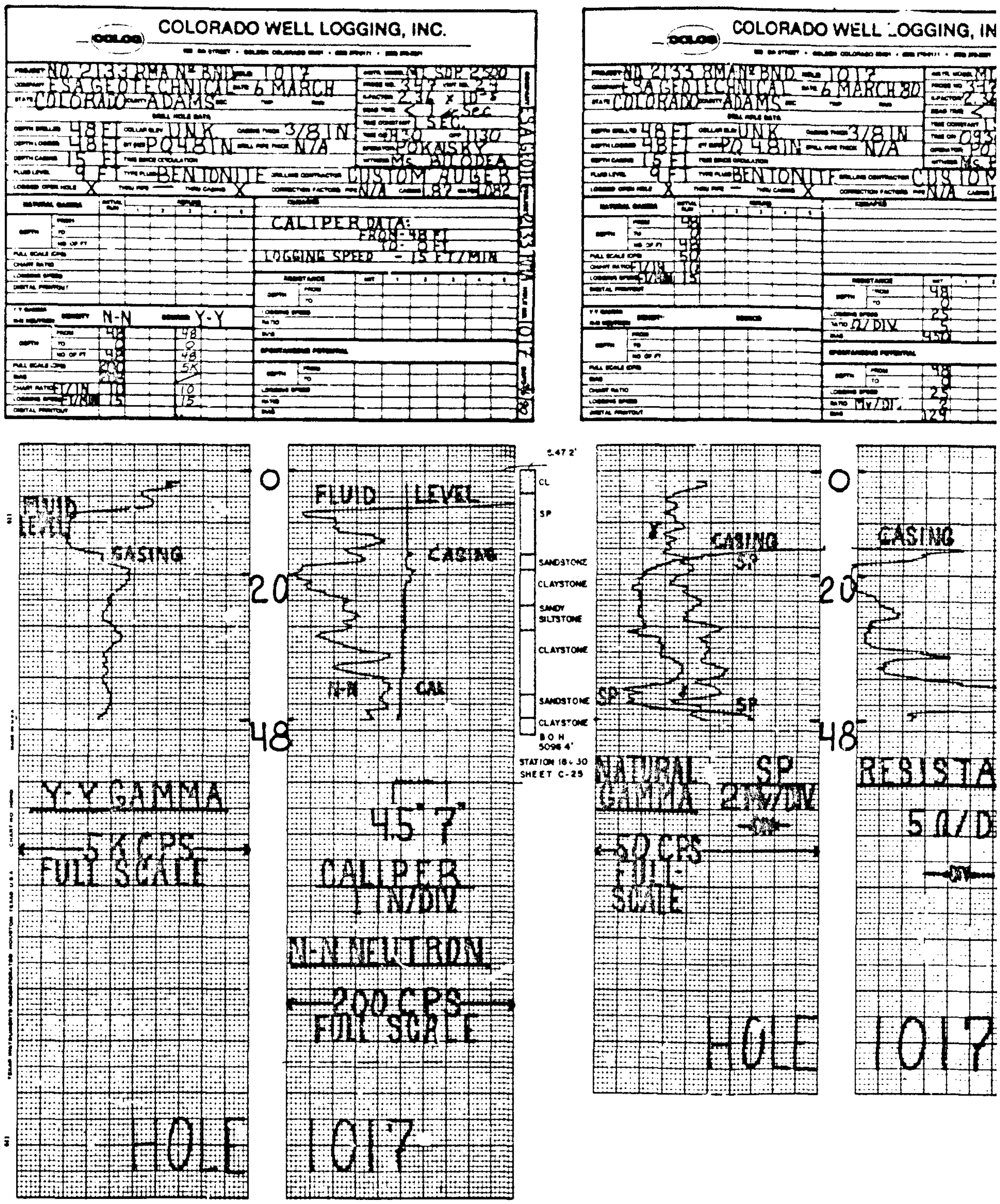
DACA45 90 R 161

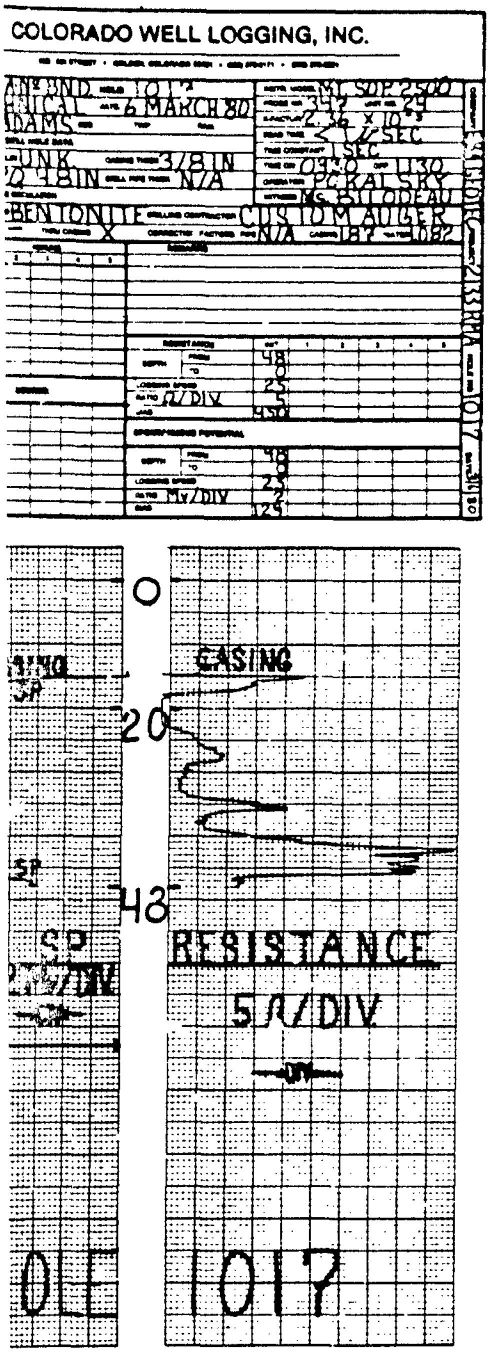
71-07-16

SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICATION NO.

$$ – THINK VALUE ENGINEERING – $$


COLORADO WELL LOGGING, INC.
NO 2133 RMA Nº BND
1017
ESA GEOTECHNICAL
6 MARCH
COLORADO
ADAMS
48 FT
UNK
3/8 IN
PQ 48 IN
N/A
15 FT
BENTONITE
CUSTOM AUGER
POKASKY
MS. BILODEA
CALIPER DATA:
FROM 48 FT
TO 8 FT
LOGGING SPEED - 15 FT/MIN
N-N
Y-Y
200
5K
ESA GEOTECH
2133 RMA
1017
COLORADO WELL LOGGING, IN
NO 2133 RMA Nº BND
1017
ESA GEOTECHNICAL
6 MARCH 80
COLORADO
ADAMS
48 FT
UNK
3/8 IN
PQ 48 IN
N/A
15 FT
BENTONITE
CUSTOM
N/A
Ω/DIV
MV/DIV
0
FLUID LEVEL
CASING
20
48
Y-Y GAMMA
5K CPS FULL SCALE
FLUID LEVEL
N-N
CAL
4.5 7
CALIPER 1 IN/DIV
N-N NEUTRON
200 CPS FULL SCALE
HOLE 1017
5472'
CL
SP
SANDSTONE
CLAYSTONE
SANDY SILTSTONE
CLAYSTONE
SANDSTONE
CLAYSTONE
BOH 5096.4'
STATION 18+30
SHEET C-25
Y
CASING
SP
NATURAL GAMMA
50 CPS FULL SCALE
SP 2 MV/DIV
RESISTA
5 Ω/D
HOLE 1017



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
30–45 N=7	40.7% PASSING											
80–95 N=11												
130–145 N=27	9.7% PASSING	100	96.4	93.3	89.4	79.5	63.4	43.0	28.0	18.4	13.6	10.8

GRADATION SIEVE SIZES

BEGAN CORING AT 65 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION GEOPHYSICAL BORING LOGS

SHEET 18 OF 30

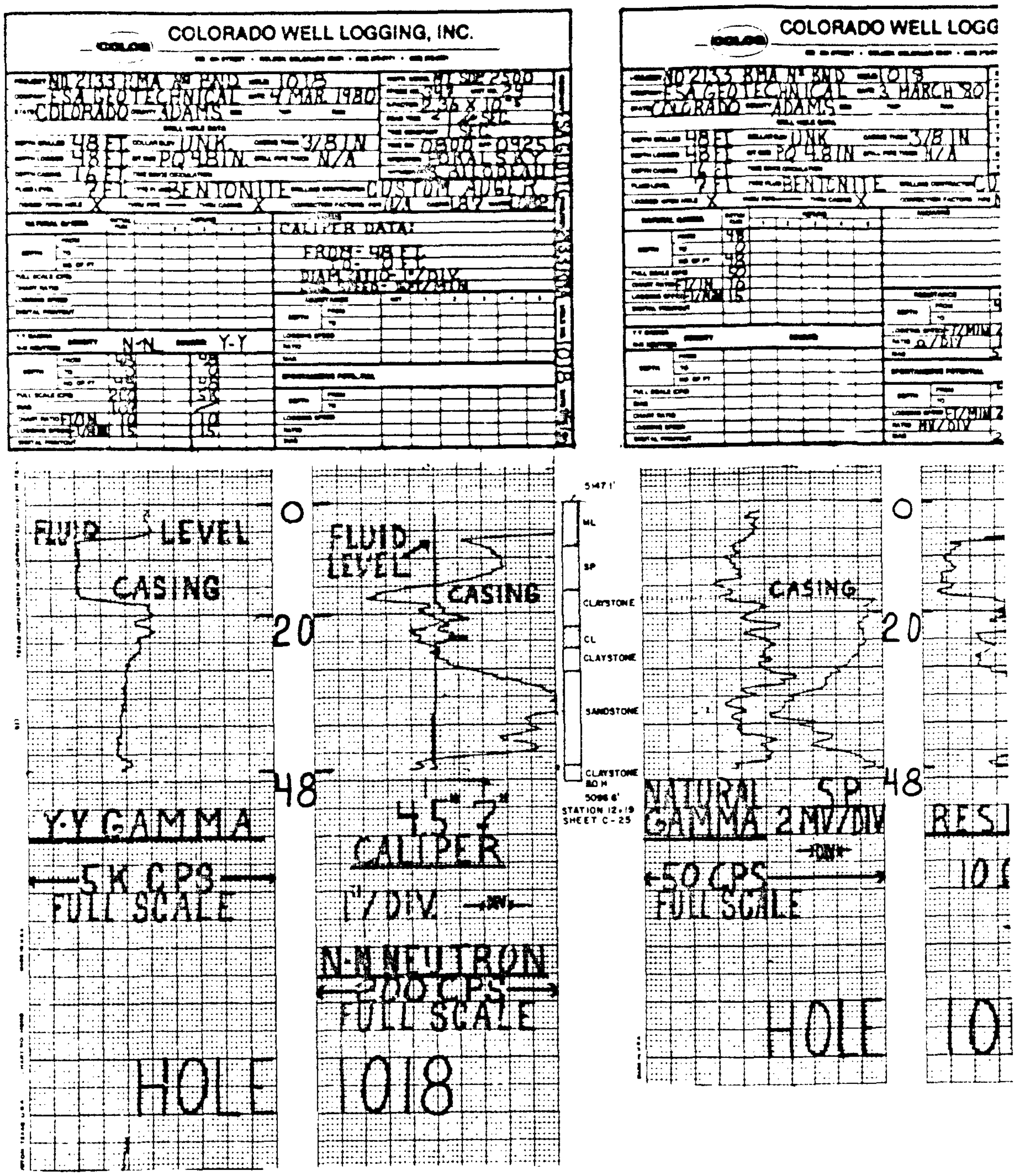
JUNE 1980

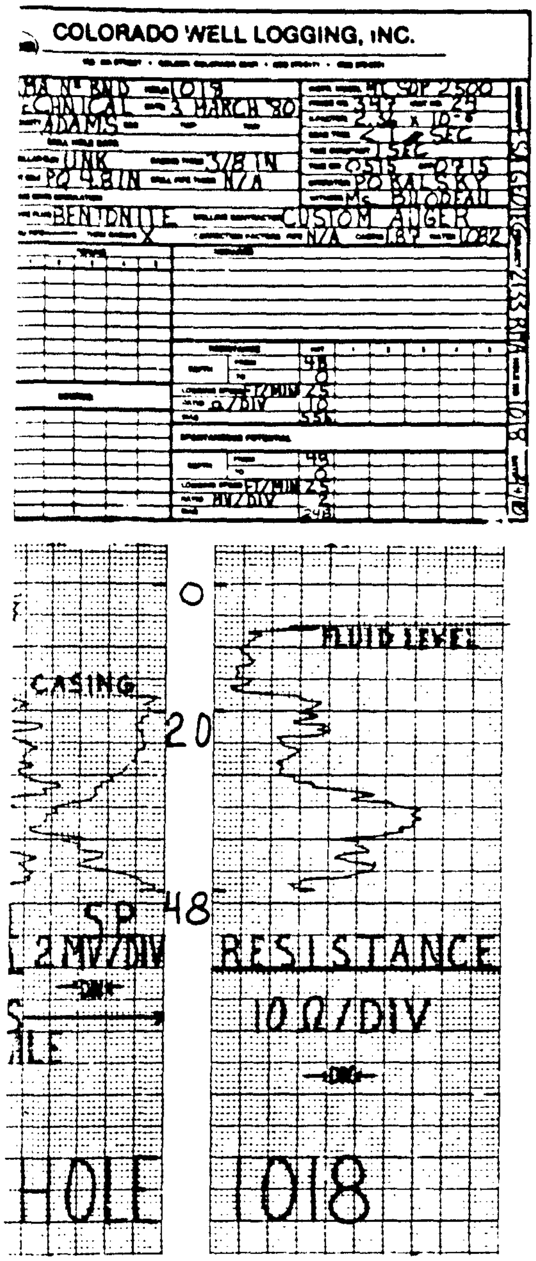
DACA45-80-R-0161

C-87 71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICATION NO.

SAFETY PAYS


COLORADO WELL LOGGING, INC.
ND 2133 RMA AP PAD 1018
ESA GEOTECHNICAL 4 MAR 1980
COLORADO ADAMS
48 FT UNK 3/8 IN
48 FT PQ 4.8 IN N/A
BENTONITE
CUSTOM AUGER
CALIPER DATA:
N-N Y-Y
COLORADO WELL LOGG
ND 2133 RMA AP PAD 1018
ESA GEOTECHNICAL 3 MARCH 80
COLORADO ADAMS
48 FT UNK 3/8 IN
48 FT PQ 4.8 IN N/A
BENTONITE
FLUID LEVEL
CASING
0
20
48
Y-Y GAMMA
5K CPS FULL SCALE
HOLE
FLUID LEVEL
CASING
4.5" 7"
CALIPER
1"/DIV
N-N NEUTRON
200 CPS FULL SCALE
1018
5147.1'
ML
SP
CLAYSTONE
CL
CLAYSTONE
SANDSTONE
CLAYSTONE
5096.6'
STATION 12+19
SHEET C-25
CASING
NATURAL GAMMA
50 CPS FULL SCALE
SP 2 MV/DIV
HOLE
RES
10



PENETRATION NO		GRADATION RESULTS % PASSING NO 200 WASH	GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
2.5-4.0	N=8	[illegible]6 % PASSING											
7.5-9.0	N=5												
12.5-14.0	N=25	7.7 % PASSING	100	98.3	97.6	95.6	94.5	91.5	72.7	39.9	9.2	0.9	7.7

BEGAN CORING AT 8.5 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 19 OF 30

JUNE 1980

DACA45-80-R-1101

SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45-7 -C-

71-07-16

C-58

$$ – THINK VALUE ENGINEERING – $$

PLATE 65

COLORADO WELL LOGGING, INC.

ND 2133 BMA NE BND — HOLE 1019

ESA GEOTECHNICAL — 5 MARCH 1980

COLORADO — ADAMS

48 FT — UNK — 3/8 IN

48 FT — PQ 4.8 IN — N/A

23.5 FT

4 FT — BENTONITE — CUSTOM AUGER

N/A

CALIPER DATA:

FROM- 48 FT

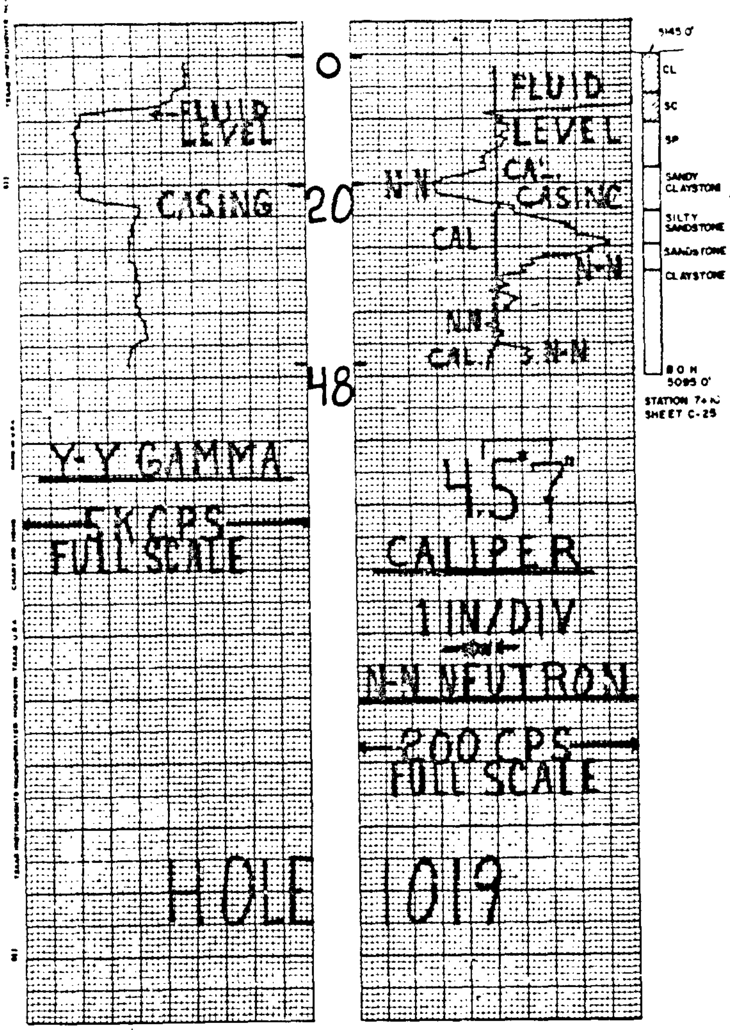
TO- 0 FT

1 IN/DIV

LOGGING SPEED - 15 FT/MIN

N-N — Y-Y

200 — 5K



COLORADO WELL LOGGING, INC.

ND 2133 BMA NE SHB — 1019

ESA GEOTECHNICAL — 5 MARCH 1980

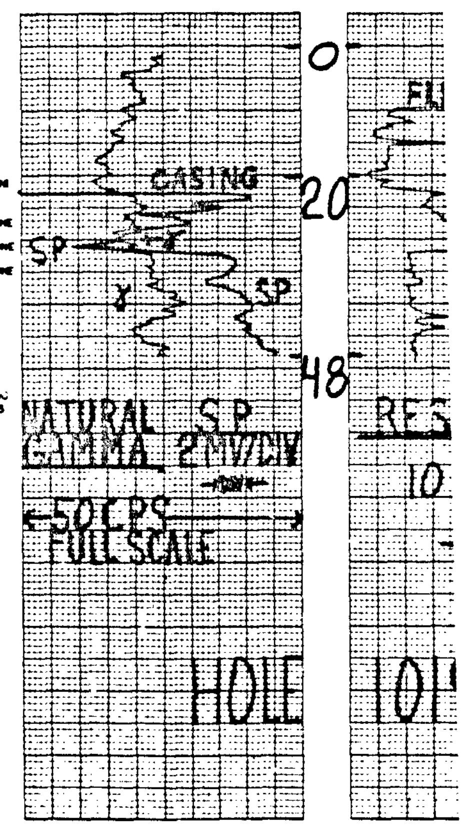
COLORADO — ADAMS

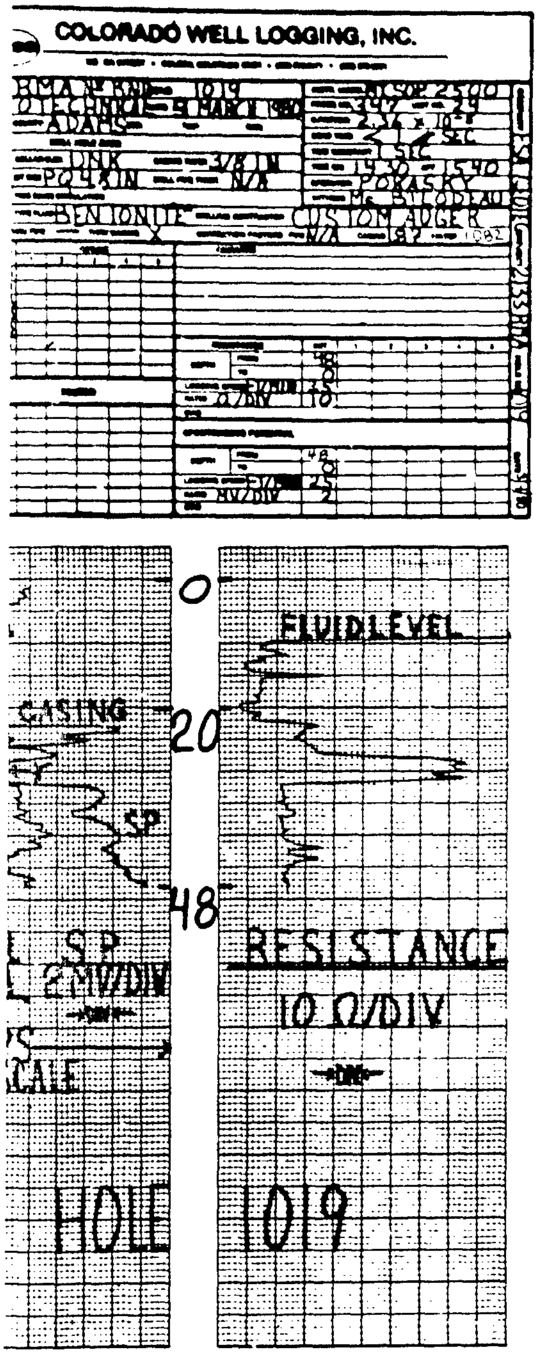
48 FT — UNK — 3/8 IN

48 FT — PQ 4.8 IN — N/A

23.5 FT

4 FT — BENTONITE





PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.7-5.2 N=2													
8.7-10.2 N=4	33.9 % PASSING												
13.7-15.2 N=42	24.7 % PASSING	100	97	87.1	87.1	85.7	82.5	74.4	55.4	39.9	32.6	28.3	25.0
18.7-20.2 N=29													
23.0-24.5 N=50 BEGAN CORING AT 24.5 FT													

BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 20 OF 30

JUNE 1980

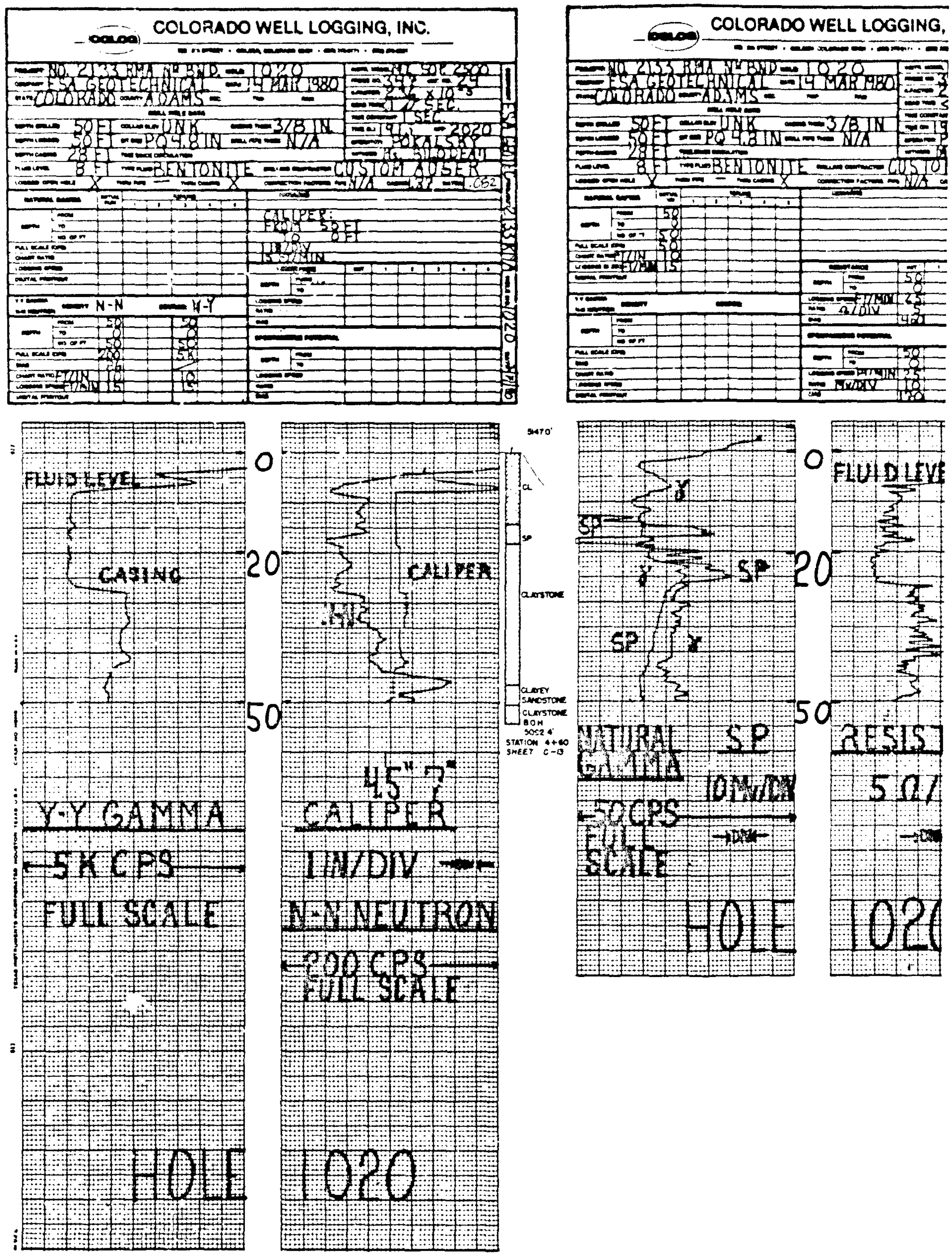
DACA45 80 R 0101

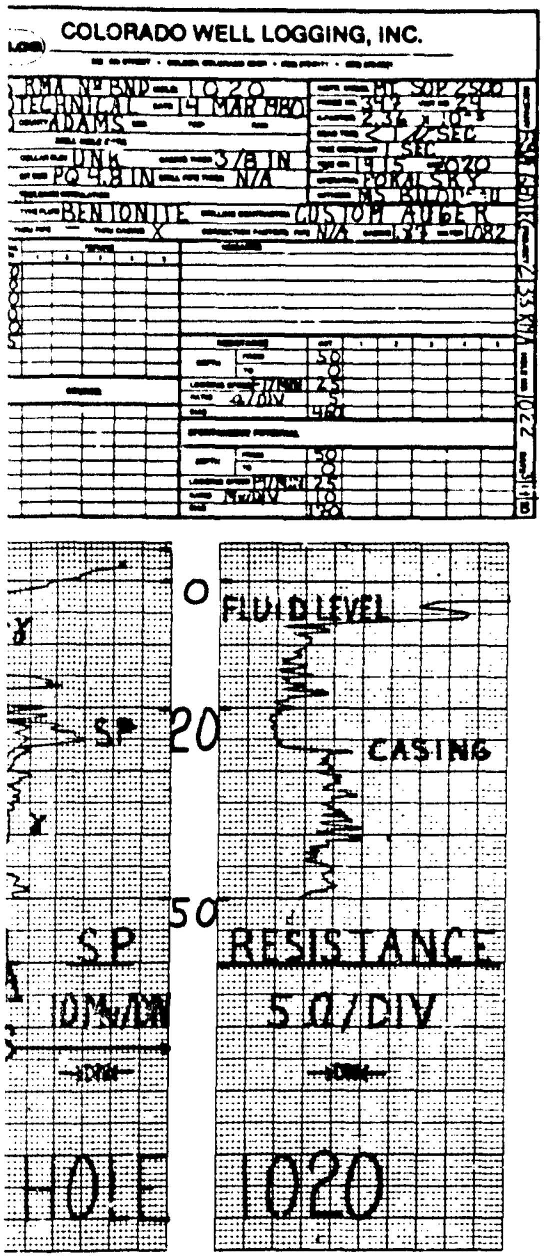
71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 C

$$ — THINK VALUE ENGINEERING — $$

PLATE 66


COLORADO WELL LOGGING, INC.
ESA GEOTECHNICAL
14 MAR 1980
COLORADO
ADAMS
BENTONITE
CALIPER
FLUID LEVEL
CASING
CALIPER
0
20
50
CL
SP
CLAYSTONE
CLAYEY SANDSTONE
CLAYSTONE
BOH
STATION 4+60
SHEET C-13
Y-Y GAMMA
5 K CPS
FULL SCALE
CALIPER
1 IN/DIV
N-N NEUTRON
200 CPS
FULL SCALE
HOLE 1020
NATURAL GAMMA
SP
50 CPS
FULL SCALE
HOLE
FLUID LEVEL
1020



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
30 - 45 N=5	75.1% PASSING											
80 - 95 N=7	63.1% PASSING											
130 - 145 N=3												
180 - 195 N=22												

BEGIN CORING AT 200 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY
BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 21 OF 30

JUNE 1980

DACA45-80-R-101

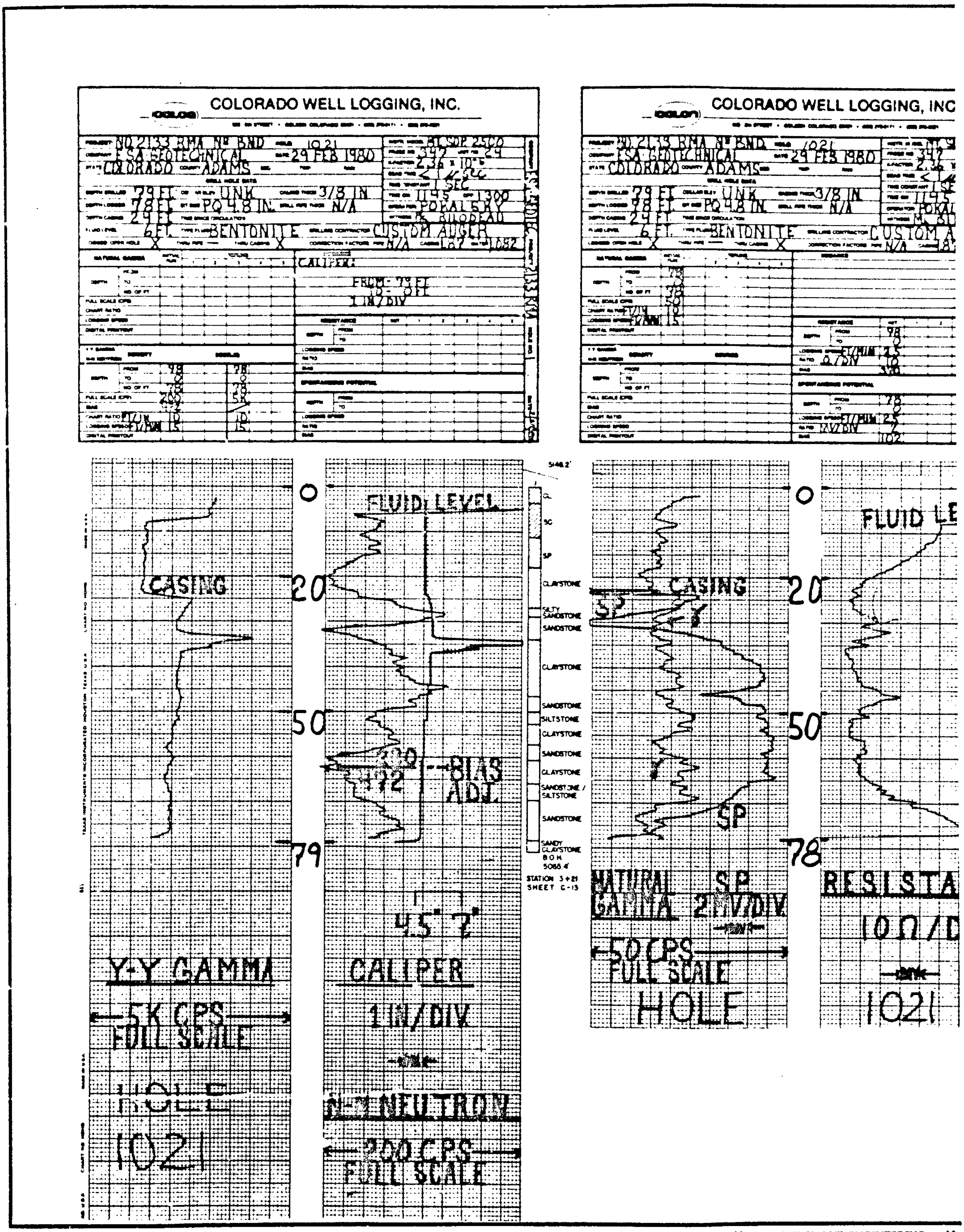
71-07-16

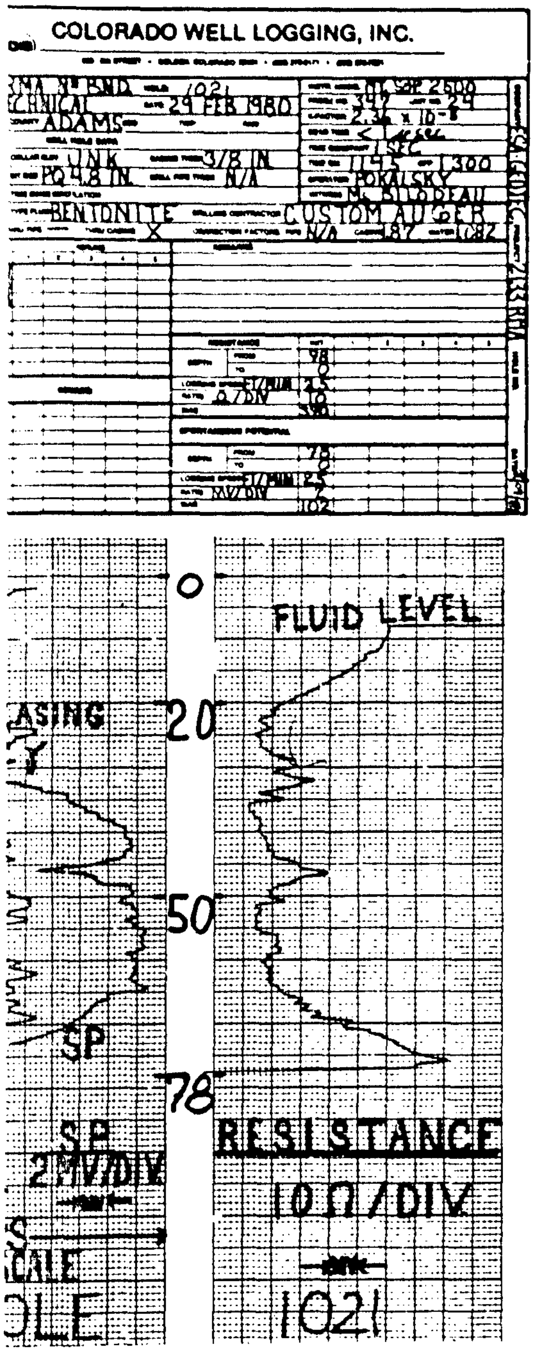
C-80

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICATION NO.

$$ – THINK VALUE ENGINEERING – $$

PLATE 67


COLORADO WELL LOGGING, INC.
ESA GEOTECHNICAL
COLORADO
ADAMS
29 FEB 1980
BENTONITE
CUSTOM AUGER
CALIPER
FLUID LEVEL
CASING
0
20
50
79
78
BIAS ADJ.
SP
CLAYSTONE
SANDSTONE
SILTSTONE
STATION 3+21
SHEET C-13
Y-Y GAMMA
5K CPS FULL SCALE
HOLE
1021
CALIPER
1 IN/DIV
NEUTRON
200 CPS FULL SCALE
NATURAL GAMMA
SP 2MV/DIV
50 CPS FULL SCALE
RESISTA
10 Ω/D



PENETRATION NO	GRADATION RESULTS % PASSING NO 200 WASH	GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.5-5.0 N=5	45.7% PASSING											
8.5-10.0 N=18												
13.5-15.0 N=12	8.0% PASSING	100	100	98.2	94.9	86.1	65.4	31.4	15.6	11.0	9.1	8.0
18.5-20.0 N=31												

BEGAN CORING AT 23.5 FT.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 22 OF 30

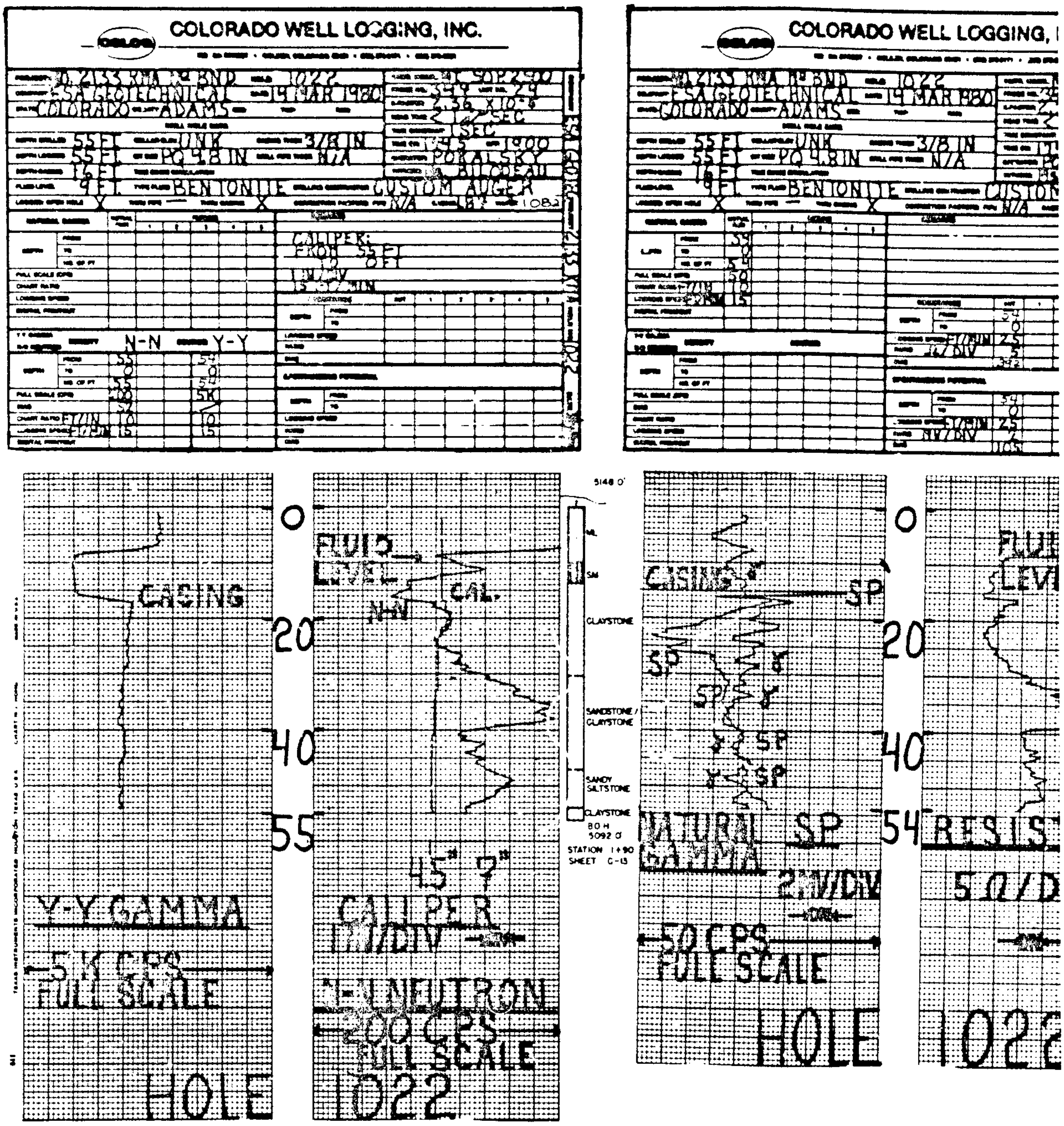
JUNE 1980

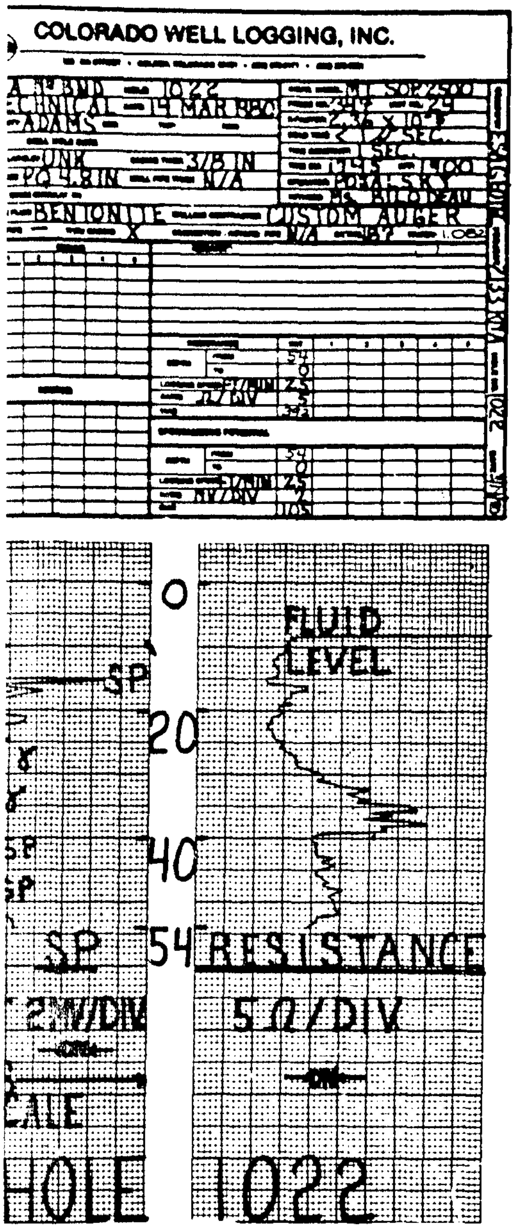
DACA45-8 ...

71-07-16

C-61

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO


COLORADO WELL LOGGING, INC.
COLORADO WELL LOGGING, I
CASING
FLUID LEVEL
CAL.
N-N
CLAYSTONE
SANDSTONE / CLAYSTONE
SANDY SILTSTONE
CLAYSTONE
BO H
5092.0
STATION 1+90
SHEET C-13
5148.0'
Y-Y GAMMA
5K CPS FULL SCALE
HOLE
CALIPER 1 IN/DIV
N-N NEUTRON
200 CPS FULL SCALE
1022
CASING
SP
NATURAL GAMMA
SP 2MV/DIV
50 CPS FULL SCALE
HOLE
RESIST
1022



PENETRATION NO.	GRADATION RESULTS % PASSING NO 200 WASH	GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
37-52 N=5	52.0% PASSING											
87-102 N=14	49.5% PASSING											
37-62 N=29												

BEGAN CORING AT 65 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

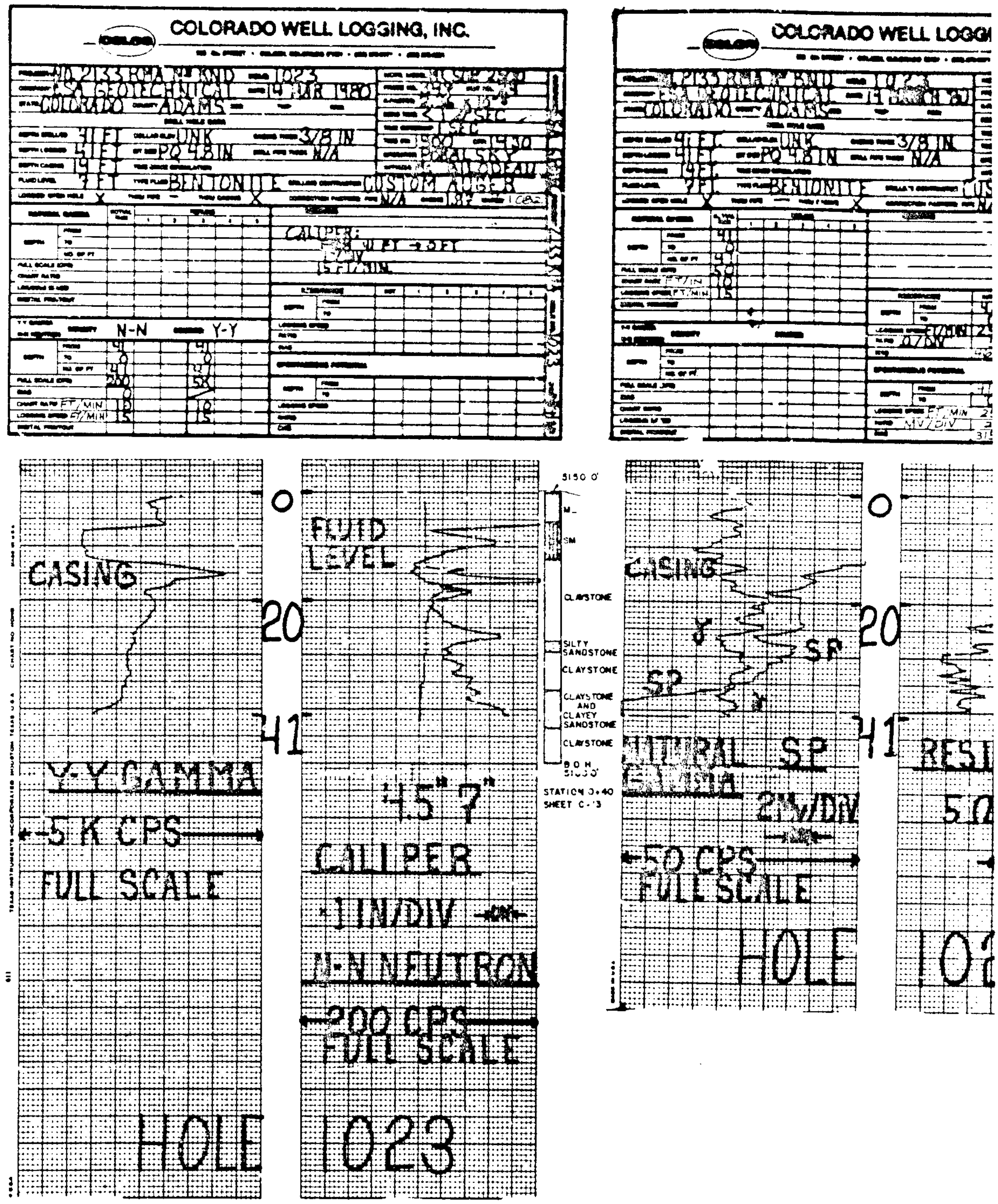
REVISIONS	
PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI	U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA
ROCKY MOUNTAIN ARSENAL	COMMERCE CITY, COLORADO
LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION GEOPHYSICAL BORING LOGS SHEET 23 OF 30	
DATE	JUNE 1980
	DACA45-80-R-0101
	71-07-16

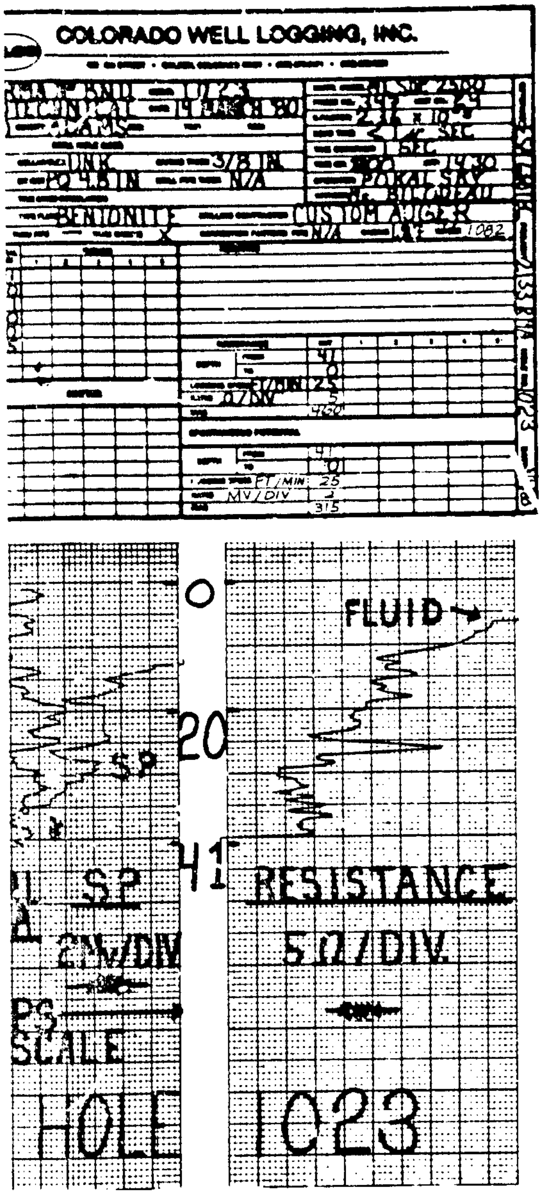
SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 C0 MODIFICATION NO.

PLATE 69

$$ – THINK VALUE ENGINEERING – $$


COLORADO WELL LOGGING, INC.
CASING
FLUID LEVEL
0
20
41
Y-Y GAMMA
5 K CPS
FULL SCALE
4.5"-7"
CALIPER
1 IN/DIV
N-N NEUTRON
200 CPS
FULL SCALE
HOLE 1023
3150.0'
CLAYSTONE
SILTY SANDSTONE
CLAYSTONE
CLAYSTONE AND CLAYEY SANDSTONE
CLAYSTONE
STATION 0+40
SHEET C-13
SP
NATURAL GAMMA
SP
2MV/DIV
50 CPS
FULL SCALE
HOLE
RES
102



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.0-4.5 N=6	70.6 % PASSING											
8.0-9.5 N=7	34 % PASSING											
13.0-14.5 N=23												

(GRADATION SIEVE SIZES: 1" through #200)

BEGAN CORING AT 15.0 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPRD

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

GEOPHYSICAL BORING LOGS SHEET 24 OF 30

SAFETY PAYS

JUNE 1981

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICATION NO.

71-07-16

COLOG COLORADO WELL LOGGING, INC.

PROJECT: NO 2133 RMA N° BND — HOLE: 1024
COMPANY: ESA GEOTECHNICAL — DATE: 29 FEB 1980
STATE: COLORADO — COUNTY: ADAMS

METER MODEL: ML SDP 2500
PROBE NO: 347 — UNIT NO: 24
K FACTOR: 2.36 × 10⁻⁶
DEAD TIME: < 1 μ SEC
TIME CONSTANT: 1 SEC
TIME ON: 1000 — OFF: 1140
OPERATOR: POKALSKY
WITNESS: Ms. BILODEAU

DRILL HOLE DATA

DEPTH DRILLED: 48 FT — COLLAR ELEV: UNK. — CASING THICK: 3/8 IN
DEPTH LOGGED: 47 FT — BIT SIZE: PQ 4.8 IN — DRILL PIPE THICK: N/A
DEPTH CASING: 18 FT — TIME SINCE CIRCULATION:
FLUID LEVEL: 11 FT — TYPE FLUID: BENTONITE — DRILLING CONTRACTOR: CUSTOM AUGER
LOGGED OPEN HOLE: X — THRU PIPE: — — THRU CASING: X — CORRECTION FACTORS: PIPE N/A — CASING 1.87 — WATER 1.082

CLIENT: ESA GEOTECHNICAL — PROJECT: 33 RMA — HOLE NO: 1024 — DATE: 2/29/80

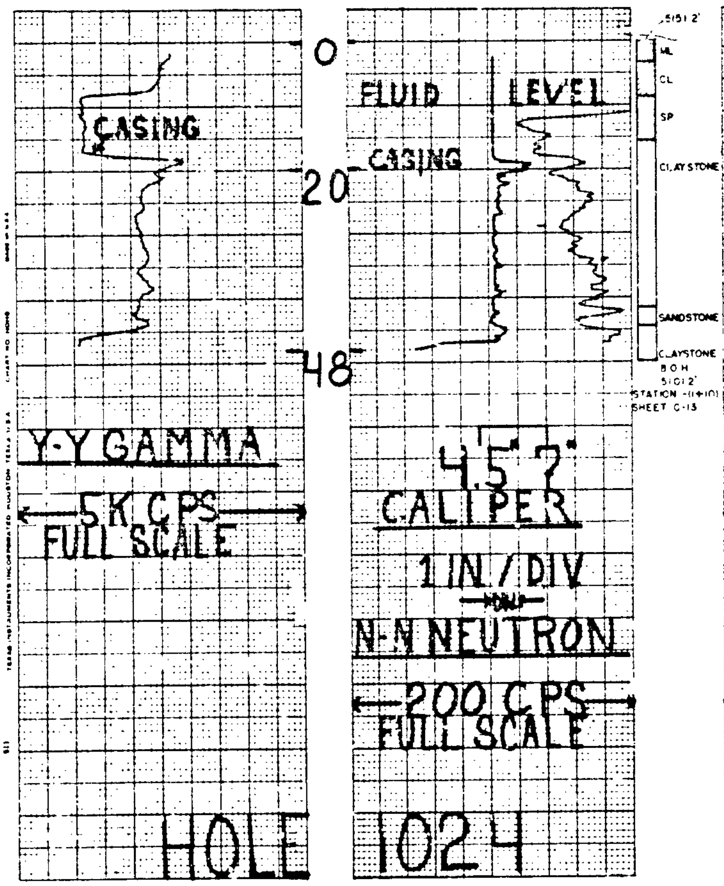
NATURAL GAMMA		INITIAL RUN	RERUNS 1	2	3	4	5
DEPTH	FROM						
	TO						
	NO OF FT						
FULL SCALE (CPS)							
CHART RATIO							
LOGGING SPEED							
DIGITAL PRINTOUT							

REMARKS: CALIPER DATA: FROM 48 TO 8 1 IN/DIV

RESISTANCE		INIT	1	2	3	4	5
DEPTH	FROM						
	TO						
LOGGING SPEED							
RATIO							
BIAS							

Y-Y GAMMA / N-N NEUTRON		DENSITY: N-N	SOURCE: Y-Y
DEPTH	FROM	47	47
	TO	0	0
	NO OF FT	47	47
FULL SCALE (CPS)		200	5K
BIAS		0	
CHART RATIO FT/IN		10	10
LOGGING SPEED FT/MIN		15	15
DIGITAL PRINTOUT			

SPONTANEOUS POTENTIAL		
DEPTH	FROM	
	TO	
LOGGING SPEED		
RATIO		
BIAS		



COLOG COLORADO WELL LOG

PROJECT: NO 2133 RMA N° BND — HOLE: 1024
COMPANY: ESA GEOTECHNICAL — DATE: 29 FEB 1980
STATE: COLORADO — COUNTY: ADAMS

DRILL HOLE DATA

DEPTH DRILLED: 48 FT — COLLAR ELEV: UNK. — CASING THICK: 3/8 IN
DEPTH LOGGED: 47 FT — BIT SIZE: PQ 4.8 IN — DRILL PIPE THICK: N/A
DEPTH CASING: 18 FT — TIME SINCE CIRCULATION:
FLUID LEVEL: 11 FT — TYPE FLUID: BENTONITE — DRILLING CONTRACTOR:
LOGGED OPEN HOLE: X — THRU PIPE: — — THRU CASING: X — CORRECTION FACTORS:

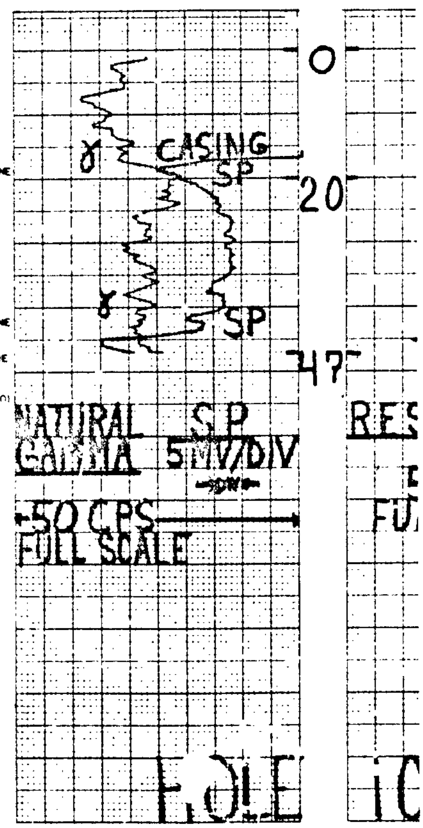
NATURAL GAMMA		INITIAL RUN	RERUNS
DEPTH	FROM	47	
	TO	0	
	NO OF FT	47	
FULL SCALE (CPS)		50	
CHART RATIO FT/IN		10	
LOGGING SPEED FT/MIN		15	
DIGITAL PRINTOUT			

Y-Y GAMMA / N-N NEUTRON	DENSITY	SOURCE
DEPTH FROM		
TO		
NO OF FT		
FULL SCALE (CPS)		
BIAS		
CHART RATIO		
LOGGING SPEED		
DIGITAL PRINTOUT		

REMARKS

RESISTANCE — DEPTH FROM / TO — LOGGING SPEED FT/MIN — RATIO Ω/DIV — BIAS

SPONTANEOUS POTENTIAL — DEPTH FROM / TO — LOGGING SPEED FT/MIN — RATIO MV/DIV — BIAS

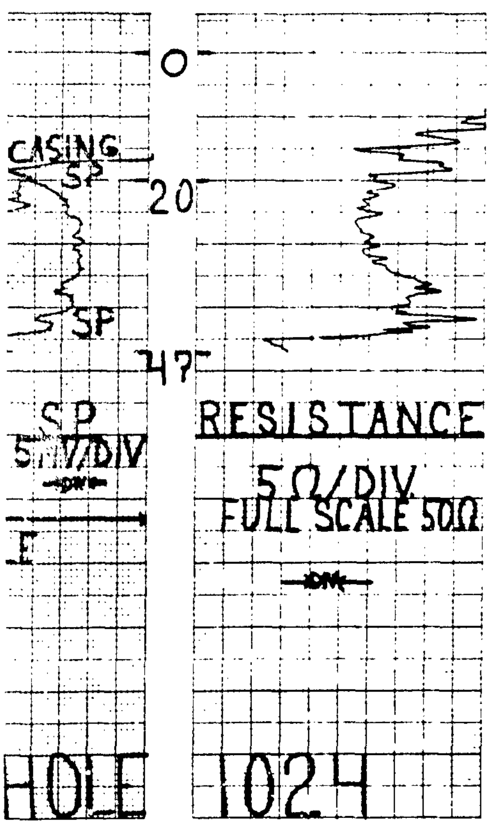


COLORADO WELL LOGGING, INC.

BND — 1024 — 29 FEB 1980 — NT SDP — 347 — 2.36 x 10⁻⁵ — SEC — 1 SEC — ADAMS — UNK — 3/8 IN — PQ 4.8 IN — N/A — 1000 — 1140 — POKALSKY — MS. BILODEAU — BENTONITE — CUSTOM AUGER — N/A — 37 — 1082 — 2133 RMA — HOLE NO 1024

RESISTANCE: DEPTH 47 / 0; FT/MIN 25; Ω/DIV 5

SPONTANEOUS POTENTIAL: DEPTH 47 / 0; FT/MIN 25; MV/DIV 5



	GRADATION RESULTS	GRADATION SIEVE SIZES										
PENETRATION NO.	% PASSING NO 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
35-50 N=5	54.8 % PASSING											
85-100 N=11	[illegible] % PASSING	% PASSING			100	99.2	95.7	19.0	43.3	26.2	21.4	9.1
35-50 N=4												
80-95 N=24												

BEGAN CORING AT 21.0 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY NORTH BOUNDARY EXPANSION

GEOPHYSICAL BORING LOGS SHEET 25 OF 30

SAFETY PAYS

JUNE 1980

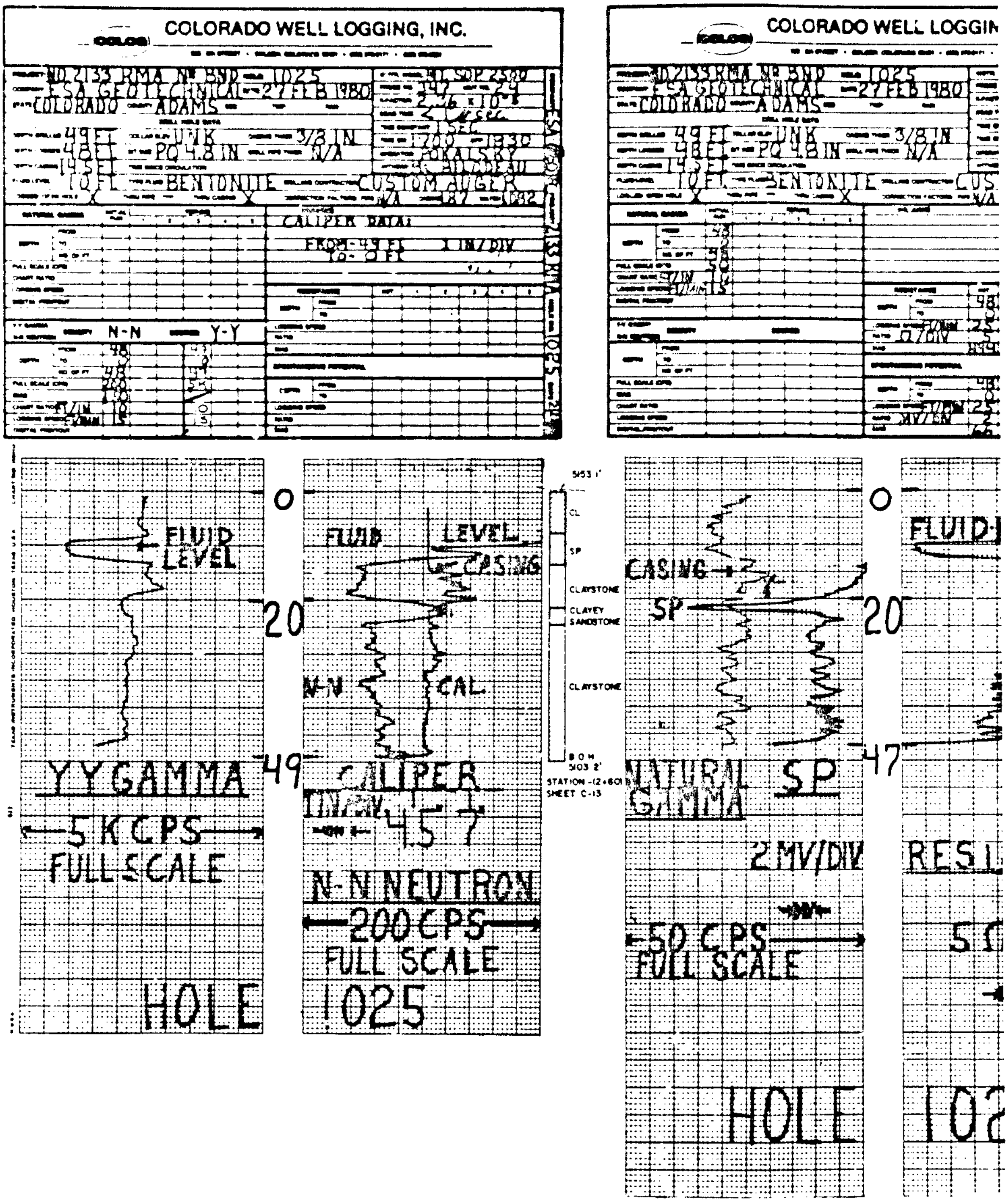
DACA45 80 R 0101

71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICATION NO.

$$ – THINK VALUE ENGINEERING – $$

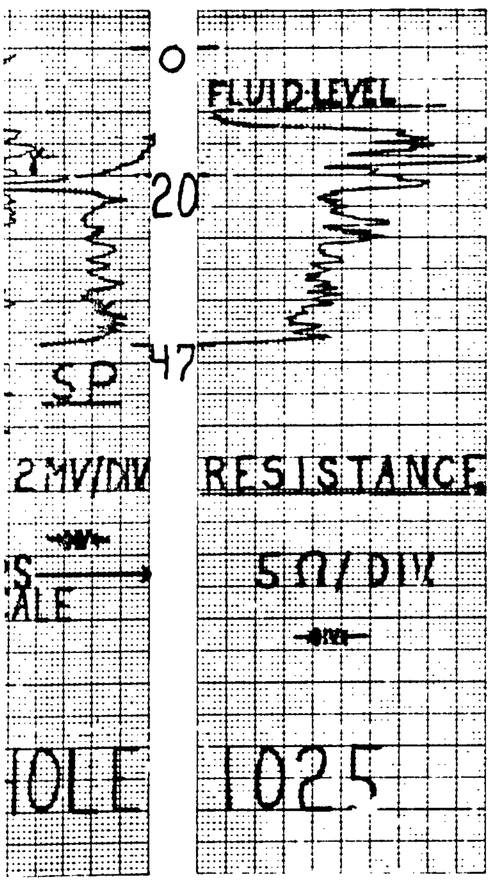
/


COLORADO WELL LOGGING, INC.
N-N
Y-Y
CALIPER DATA
COLORADO WELL LOGGIN
0
FLUID LEVEL
20
49
YYGAMMA
5 K CPS
FULL SCALE
HOLE
FLUID LEVEL
CASING
N-N
CAL
CALIPER
N-N NEUTRON
200 CPS
FULL SCALE
1025
CL
SP
CLAYSTONE
CLAYEY SANDSTONE
CLAYSTONE
B O H
STATION
SHEET C-13
CASING
SP
NATURAL GAMMA
SP
2 MV/DIV
50 CPS
FULL SCALE
HOLE
47
FLUID
RES

2

COLORADO WELL LOGGING, INC.

NBND	1025		AT SDP 2500
TECHNICAL	27 FEB 1980		242	29
ADAMS			2.36 x 10⁻³
UNK	3/8 IN		1700	1830
PC 4.8 IN	N/A		POKALSKY
BENTONITE	CUSTOM AUGER		R. BILODEAU
X	N/A	187	1082



PENETRATION NO.	GRADATION RESULTS % PASSING NO 200 MESH	GRADATION SIEVE SIZES 1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.5-5.0 N=6												
4.5-10.25 N=5	30.7% PASSING											
3.5-5.0 N=5 BEGAN CORING AT 5.5 FT												

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

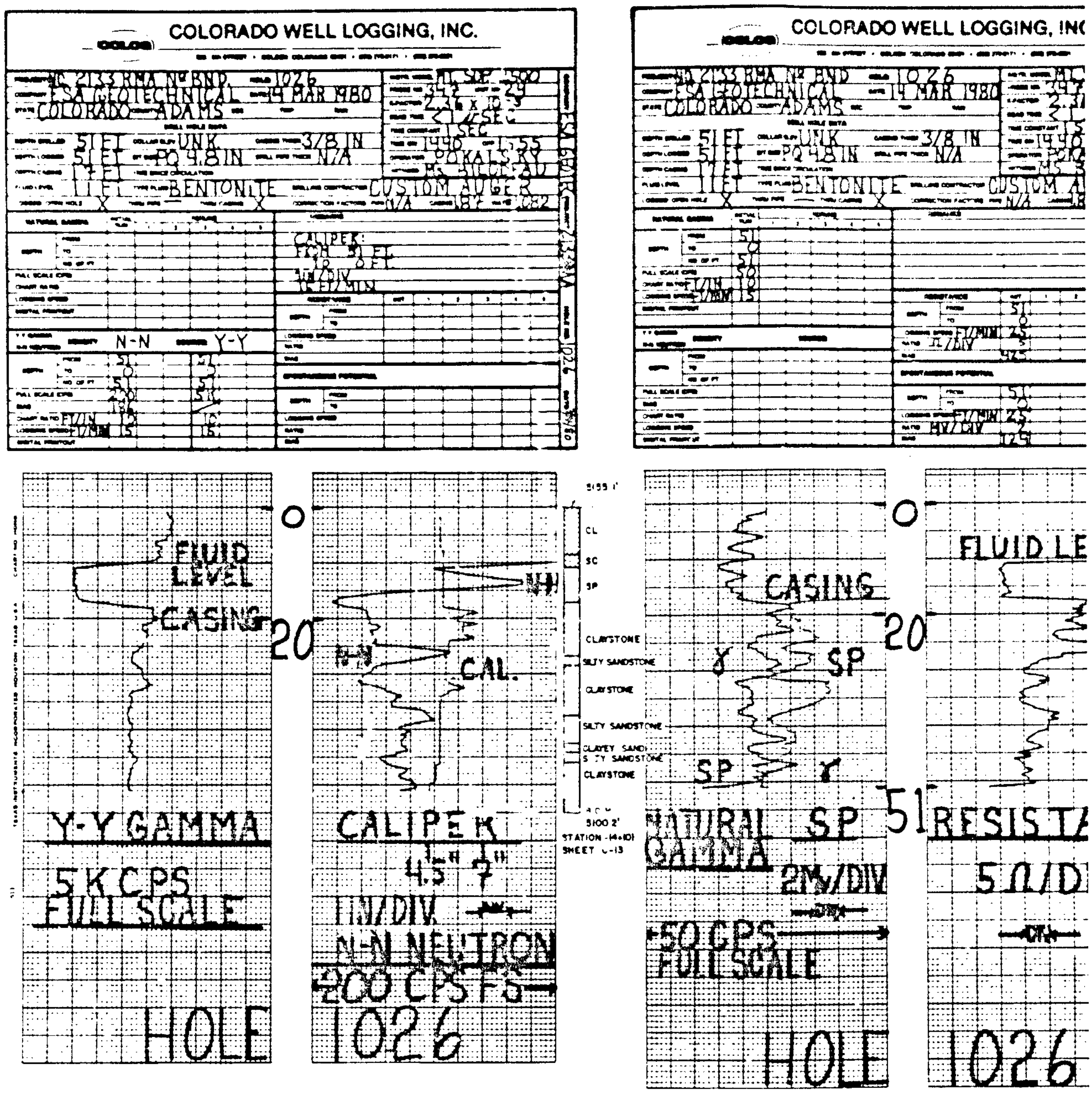
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 26 OF 30

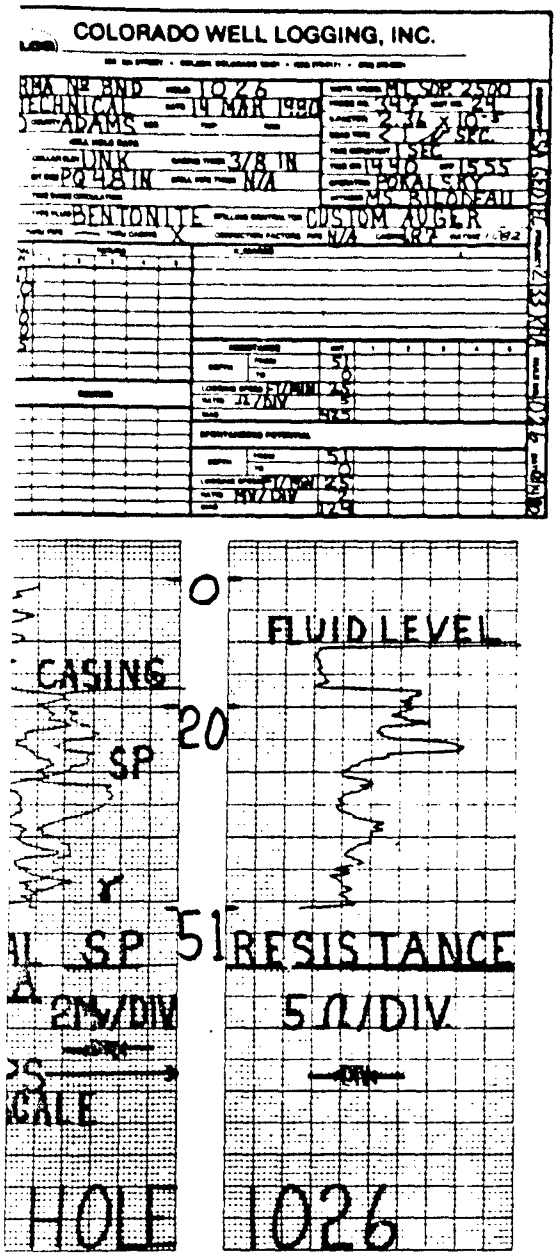
JUNE 1980

71-07-16

SAFETY PAYS

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 C0


COLORADO WELL LOGGING, INC.
COLORADO WELL LOGGING, INC
FLUID LEVEL
CASING
20
0
Y-Y GAMMA
5K CPS FULL SCALE
HOLE
CAL.
CALIPER
1IN/DIV
N-N NEUTRON
200 CPS FS
1026
CLAYSTONE
SILTY SANDSTONE
CLAYSTONE
SILTY SANDSTONE
CLAYEY SAND
SILTY SANDSTONE
CLAYSTONE
STATION
CASING
SP
SP
51
NATURAL GAMMA
SP
2MV/DIV
50 CPS FULL SCALE
HOLE
FLUID LE
RESISTA
1026



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1 1/2	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
[illegible]0–4.5 N=6													
8.0–9.5 N=3	27.9% PASSING												
13.0–14.5 N=34	44% PASSING	100	82.5	77.0	74.1	71.5	57.7	36.4	20.3	11.2	7.4	5.5	4.5
18.0–19.5 N=12													
BEGAN CORING AT 20.5 FT													

THIS DRAWING HAS BEEN REDUCED TO THREE EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

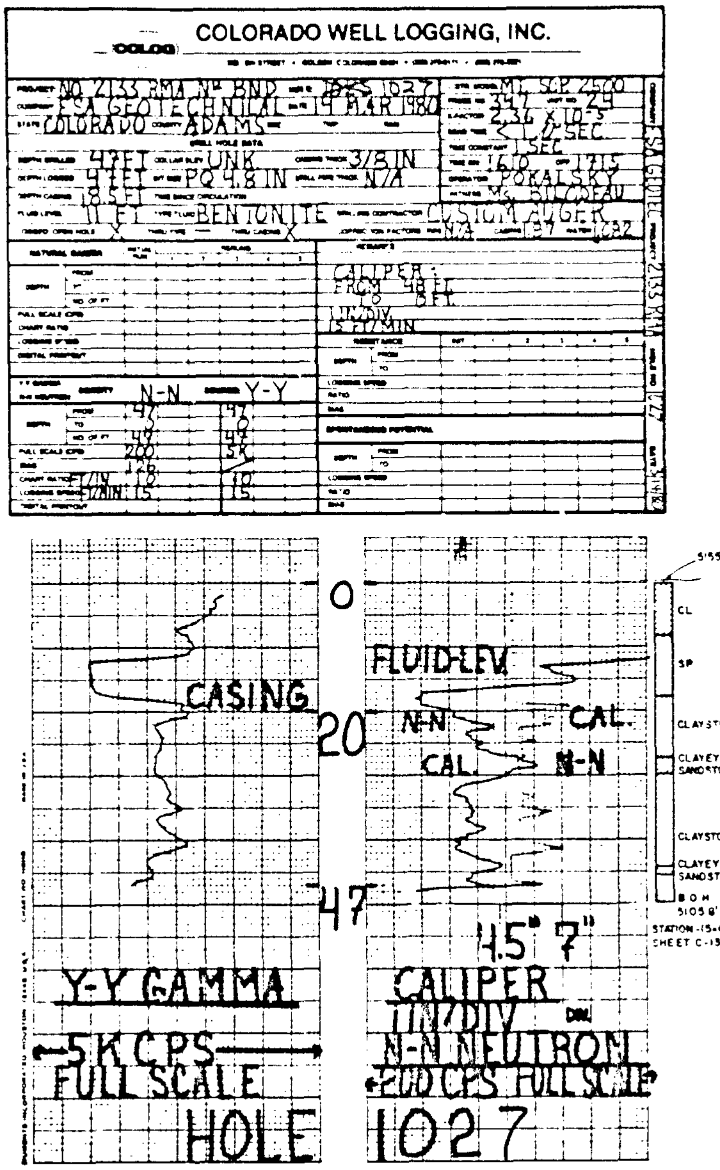
ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

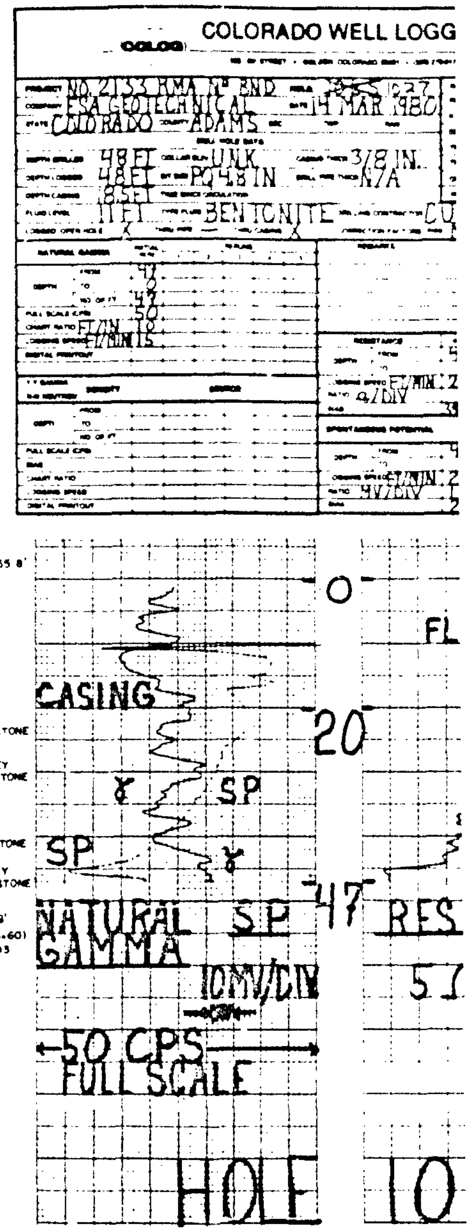
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 27 OF 30

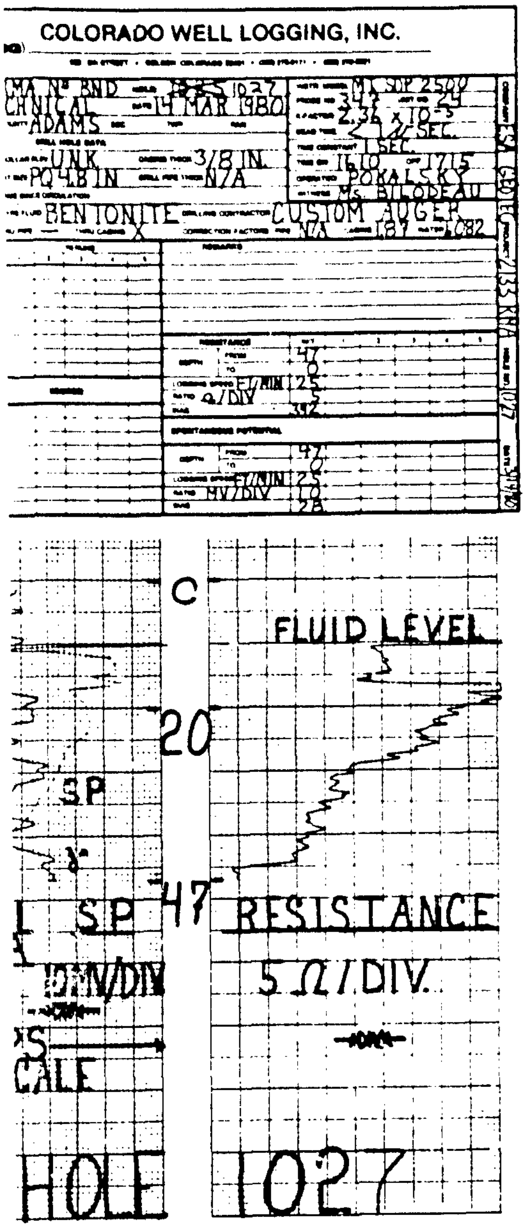
JUNE 1961

71-07-16

PLATE 73


COLORADO WELL LOGGING, INC.
NO 2133 RMA Nº BND
HOLE 1027
ESA GEOTECHNICAL
14 MAR 1980
COLORADO
ADAMS
47 FT
UNK
3/8 IN
PQ 4.8 IN
N/A
18.5 FT
11 FT
BENTONITE
CUSTOM AUGER
POKALSKY
CALIPER
FROM 48 FT
N-N
Y-Y
CASING
FLUID LEV
N-N
CAL
CAL.
N-N
0
20
47
CL
SP
CLAYSTONE
CLAYEY SANDSTONE
CLAYSTONE
CLAYEY SANDSTONE
B.O.H.
STATION -(5+60)
SHEET C-15
4.5" 7"
Y-Y GAMMA
5K CPS
FULL SCALE
CALIPER
1 IN/DIV
N-N NEUTRON
200 CPS FULL SCALE
HOLE 1027


COLORADO WELL LOGG
NO 2133 RMA Nº BND
ESA GEOTECHNICAL
14 MAR 1980
COLORADO
ADAMS
48 FT
48 FT
UNK
3/8 IN.
PQ 4.8 IN
N/A
18.5 FT
11 FT
BENTONITE
CASING
0
20
47
SP
SP
γ
γ
FL
NATURAL GAMMA
SP
10MV/DIV
RES
50 CPS
FULL SCALE
HOLE 10



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
3.5-5.0 N=5	79.7 % PASSING											
8.5-10.0 N=13												
13.5-15.0 N=25	84 % PASSING	100	884	85	773	631	429	253	69	21	94	80
18.5-19.0 N=17/6"												

BEGAN CORING AT 20.0 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY MISSOURI

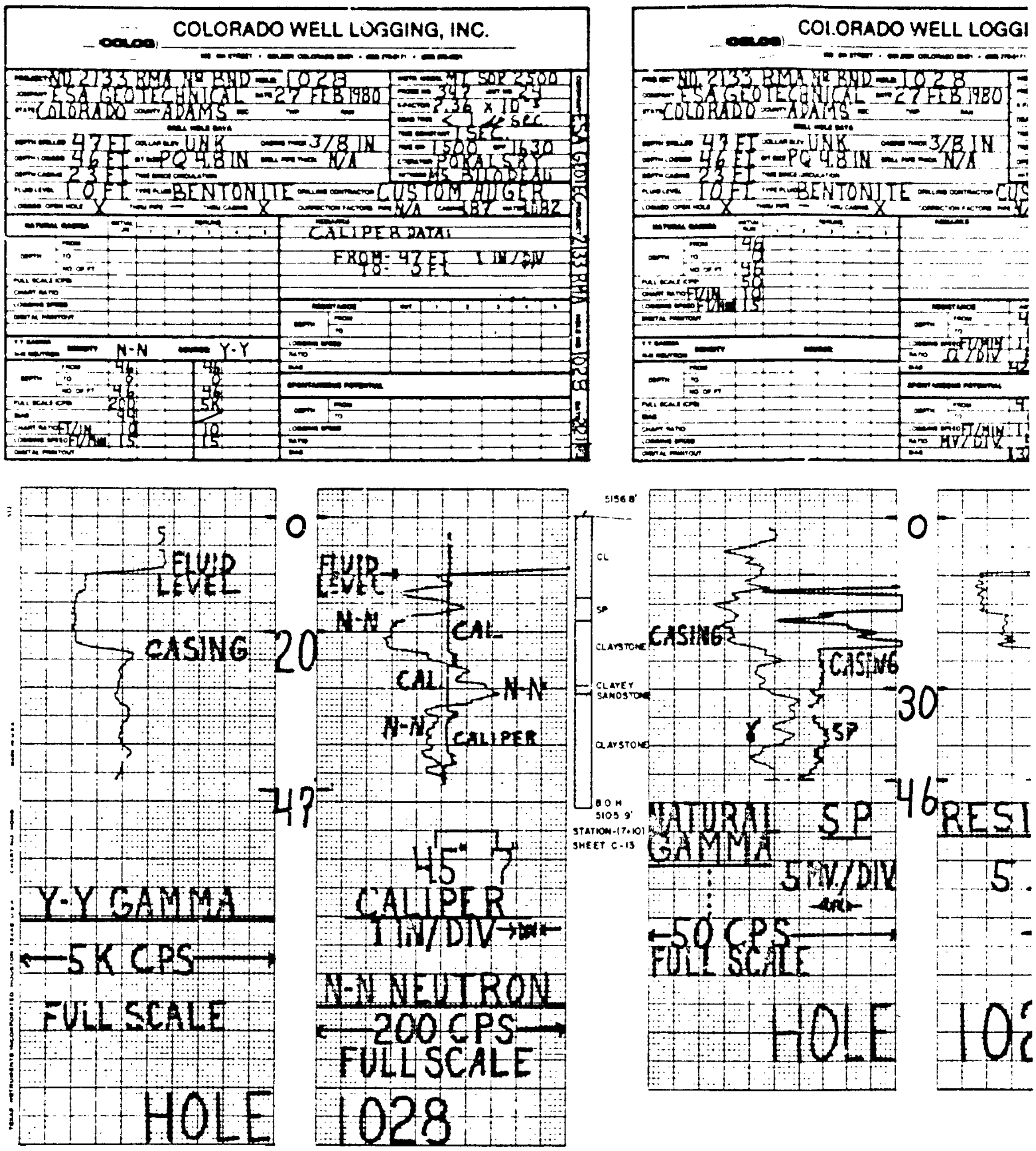
U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

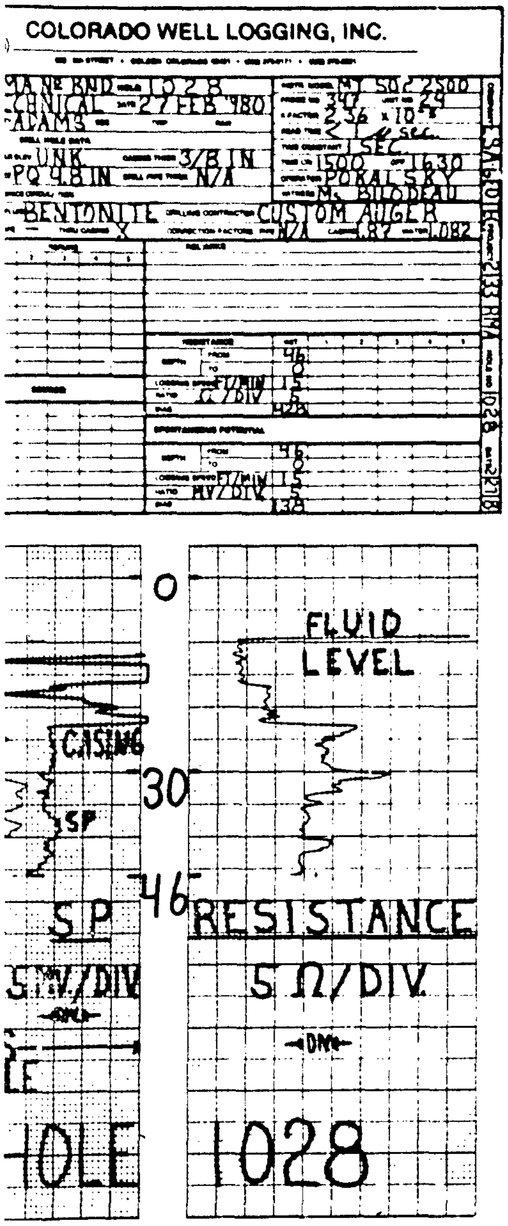
ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 28 OF 30

71-07-16

PLATE 74


COLORADO WELL LOGGING, INC.
ESA GEOTECHNICAL
COLORADO
ADAMS
27 FEB 1980
1028
BENTONITE
CUSTOM AUGER
CALIPER DATA:
FLUID LEVEL
CASING
N-N
CAL
CALIPER
CL
SP
CLAYSTONE
CLAYEY SANDSTONE
STATION-(7+10)
SHEET C-15
Y-Y GAMMA
5K CPS
FULL SCALE
HOLE
CALIPER
1 IN/DIV
N-N NEUTRON
200 CPS
FULL SCALE
1028
NATURAL GAMMA
SP
5 MV/DIV
50 CPS
FULL SCALE
HOLE



PENETRATION NO	GRADATION RESULTS % PASSING NO 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200
4.2-5.7' N=20												
9.2-10.7' N=13	97.6 % PASSING											
14.2-15.7' N=23	6.3% PASSING	100	100	100	100	97.3	83.6	49.6	21.5	10.5	7.9	6.7
19.2-20.7' N=30												

BEGAN CORING AT 24.0 FT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

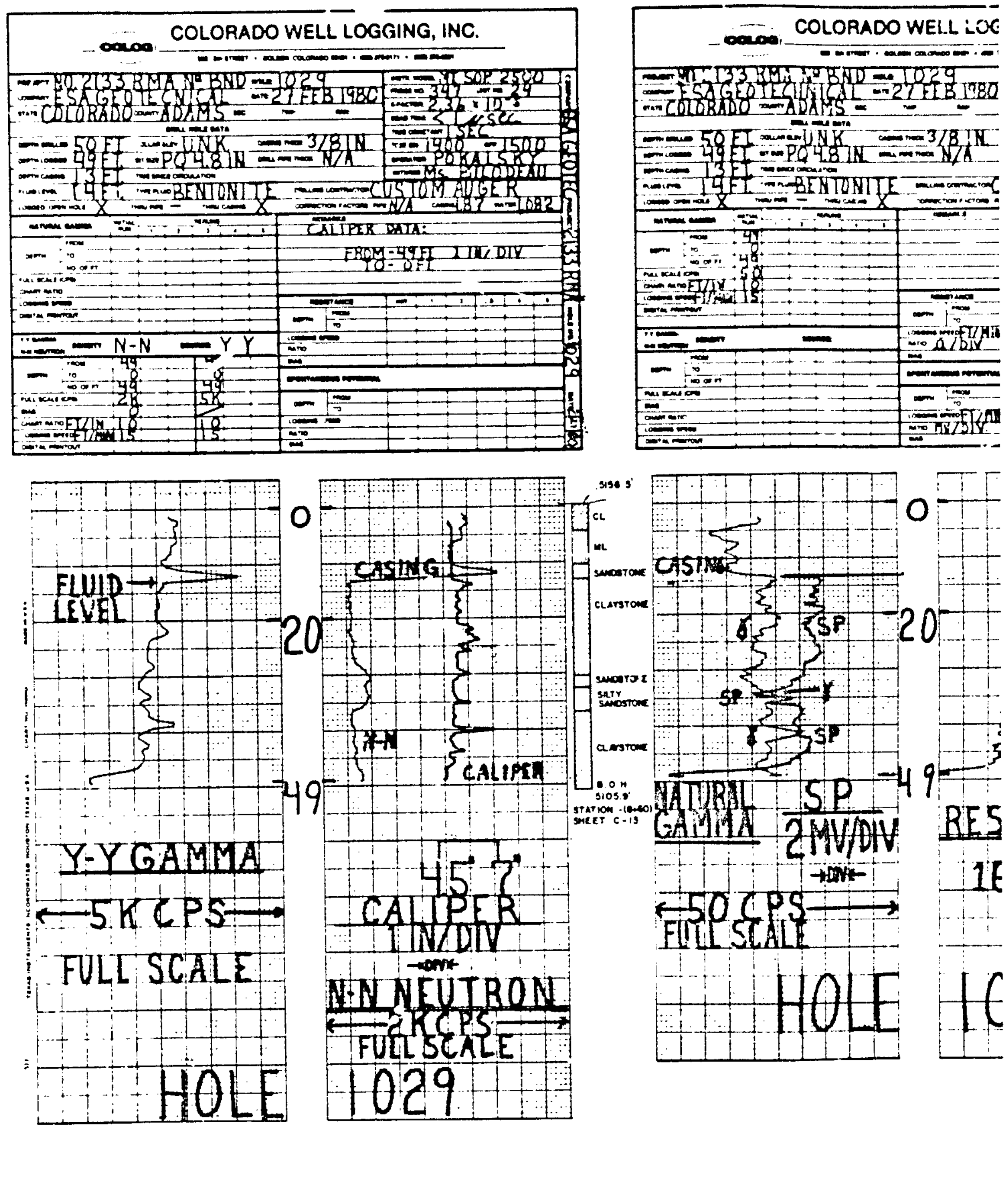
PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 29 OF 30

71-07-6


COLORADO WELL LOGGING, INC.
COLOG
BO 2133 RMA No BND
1029
ESA GEOTECHNICAL
27 FEB 1980
COLORADO
ADAMS
50 FT
UNK
3/8 IN
49 FT
PQ 4.8 IN
N/A
13 FT
14 FT
BENTONITE
CUSTOM AUGER
CALIPER DATA:
FROM -49 FT 1 IN/DIV
TO - 0 FT
N-N
Y Y
FLUID LEVEL
CASING
N-N
CALIPER
Y-Y GAMMA
5K CPS
FULL SCALE
HOLE
45.7
CALIPER
1 IN/DIV
N-N NEUTRON
2K CPS
FULL SCALE
1029
0
20
49
CL
ML
SANDSTONE
CLAYSTONE
SILTY SANDSTONE
CLAYSTONE
B.O.H.
5105.9'
STATION -(8+60)
SHEET C-13
CASING
SP
NATURAL GAMMA
SP
2 MV/DIV
50 CPS
FULL SCALE
HOLE

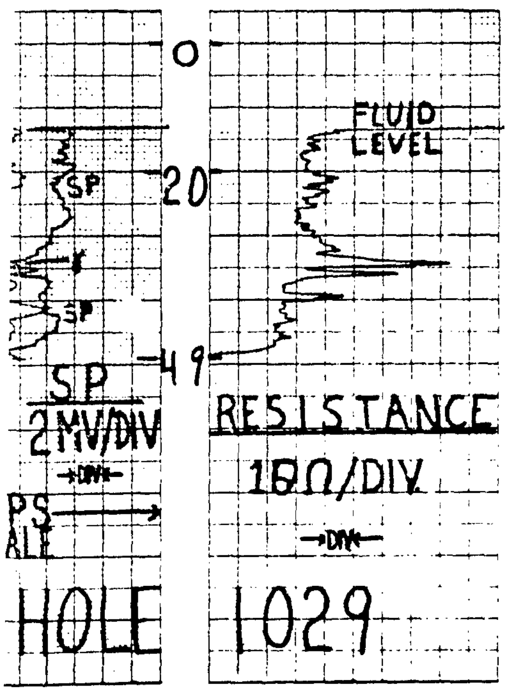
COLORADO WELL LOGGING, INC.

...IA Nº BND	HOLE 1029		ML 50P 2500
...ECHNICAL	DATE 27 FEB 1980		347 / 2
ADAMS			2.36 x 10^-5
UNK	CASING 3/8 IN.		< 1 μ sec
PQ 4.8 IN.	N/A		1 SEC
BENTONITE	CUSTOM AUGER		1400 / 1500
X	N/A	187 / 1082	POKALSKY
			M. BILODEAU

RESISTANCE: DEPTH FROM 49, TO 0; LOGGING SPEED FT/MIN 15; RATIO Ω/DIV 10; 358

SPONTANEOUS POTENTIAL: DEPTH FROM 49, TO 0; LOGGING SPEED FT/MIN 15; RATIO MV/DIV 5; -13

SA GEOTEC · 2133 RMA · 1029 · 3/80



PENETRATION NO.	GRADATION RESULTS % PASSING NO. 200 WASH	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#50	#100	#200
30-45 N=7	55.7 % PASSING											
80-95 N=28 BEGAN CORING AT 10.2 FT												

(GRADATION SIEVE SIZES)

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY MISSOURI

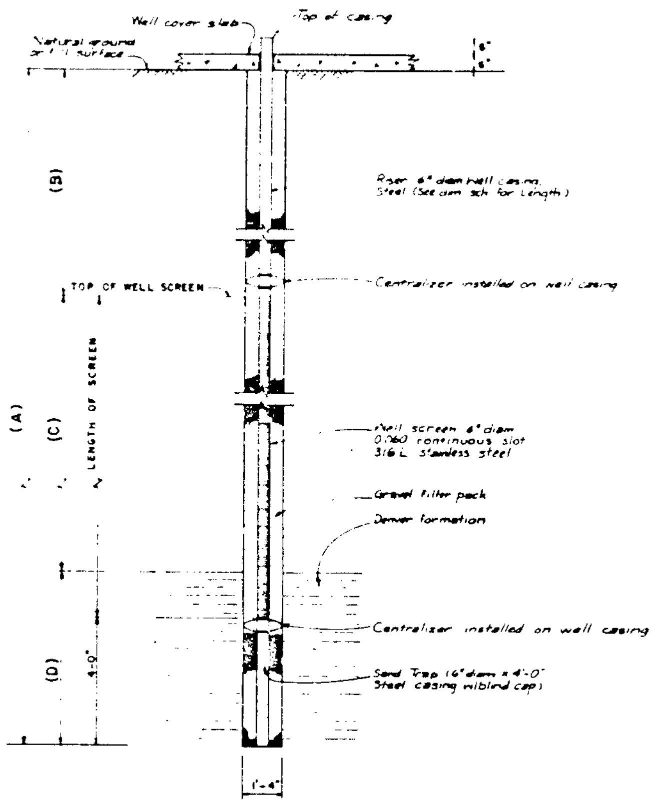
U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOPHYSICAL BORING LOGS
SHEET 30 OF 30

SAFETY PAYS

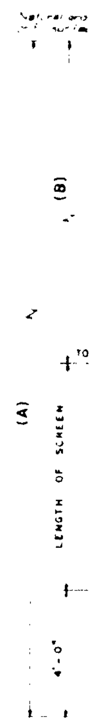
T-07-6

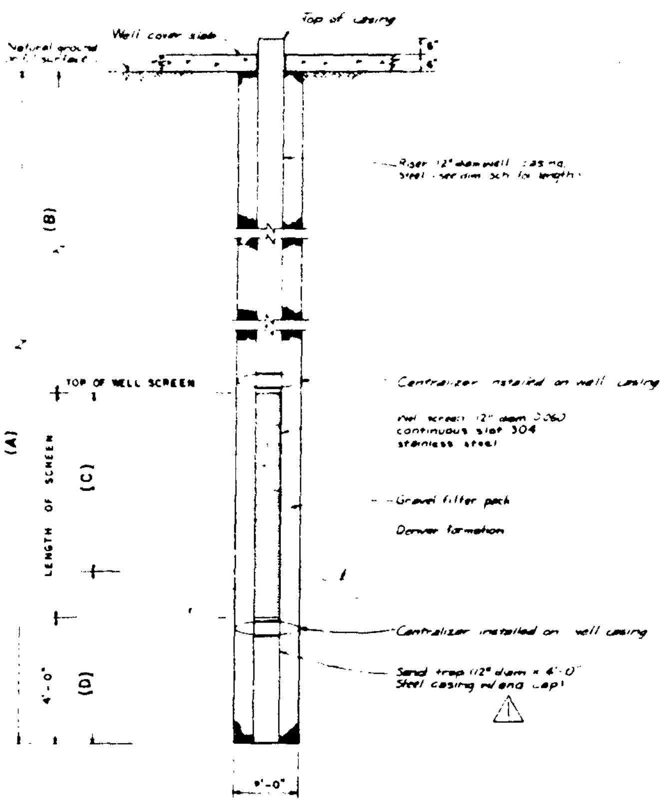


DEWATER WELLS

DW-7 THROUGH DW-35

NOT TO SCALE





RECHARGE WELLS

RW-13 THROUGH RW-38

NOT TO SCALE

DEWATER AND RECHARGE WELLS
DIMENSION SCHEDULE

WELL NUMBER	TOP OF CASING ELEVATION	A (FT.)	B (FT.)	C (FT.)	D (FT.)	RISER LENGTH (FT.)	SCREEN LENGTH (FT.)
DW-1R*	5148.8	20.8	12.8	3.0	5.0	13.8	3.0
DW-2R*	5145.8	19.3	11.3	3.0	5.0	12.3	3.0
DW-3R*	5149.2	22.0	14.0	3.0	5.0	15.0	3.0
DW-4R*	5155.7	29.3	21.3	4.0	5.0	21.3	4.0
DW-5R*	5157.0	34.3	21.3	8.0	5.0	22.3	8.0
DW-6R*	5157.8	32.0	27	5.0	5.0	23.1	5.0
DW-7	5157.1	29.1	22.	3.0	4.0	23.1	3.0
DW-8	5154.2	28.2	21.	3.0	4.0	22.2	3.0
DW-9	5155.8	29.8	19.8	6.0	4.0	20.8	6.0
DW-10	5153.2	31.2	17.2	5.0	8.0	18.2	10.0
DW-11	5152.0	27.5	16.5	[illegible]	4.0	17.5	7.0
DW-12	5154.2	28.7	17.7	[illegible]	4.2	18.7	7.0
DW-13	5152.5	28.5	16.5	9.0	4.0	17.5	8.0
DW-14	5148.6	30.1	15.1	10.	4.3	16.1	11.0
DW-15	5148.2	28.7	14.7	10.0	4.0	15.7	10.0
DW-16	5146.3	25.8	11.8	10.0	4.	12.8	10.0
DW-17	5146.4	23.9	12.9	7.0	4.	13.9	7.0
DW-18	5146.6	26.1	14.1	7.5	4.5	15.1	8.0
DW-19	5145.3	26.8	12.8	10.0	4.0	13.8	10.0
DW-20	5144.0	28.0	16.0	8.0	4.0	17.0	8.0
DW-21	5142.7	30.7	18.7	7.5	4.5	19.7	8.0
DW-22	5142.5	32.0	19.0	8.5	4.5	20.0	9.0
DW-23	5142.5	29.5	12.5	13.0	4.0	13.5	13.0
DW-24	5143.9	26.9	12.9	9.0	4.	13.9	8.0
DW-25	5144.5	26.0	14.0	7.8	4.	15.0	8.0
DW-26	5148.3	27.3	14.3	9.0	4.0	15.3	9.0
DW-27	5148.8	27.1	14.3	8.8	4.2	15.3	9.0
DW-28	5149.2	25.2	14.2	6.0	5.0	15.2	7.0
DW-29	5150.3	23.3	14.3	4.0	5.0	15.3	5.0
DW-30	5155.9	30.3	23.3	3.0	4.0	24.3	3.0
DW-31	5140.3	25.3	17.3	3.0	5.0	8.3	4.0
DW-32	5156.9	24.8	15.9	4.7	4.3	16.9	5.0
DW-33	5158.1	23.1	14.1	4.5	4.5	15.1	4.0
DW-34	5172.5	27.0	15.0	8.0	4.0	16.0	8.0
DW-35	5140.3	22.8	13.8	4.0	5.0	14.8	5.0
RW-13	5151.7	23.7	12.7	6.8	4.2	13.	7.0
RW-14	5144.3	17.8	6.8	7.0	4.0	7.8	7.0
RW-15	5144.0	18.5	8.5	7.0	4.0	9.5	7.0
RW-16	5145.7	21.2	6.2	10.8	4.2	7.2	11.0
RW-17	5144.7	23.7	7.7	12.0	4.0	8.7	12.0
RW-18	5142.0	22.0	6.0	12.0	4.0	7.0	12.0
RW-19	5142.5	22.5	8.5	10.0	4.0	9.5	10.0
RW-20	5142.5	23.0	9.0	10.0	4.0	10.0	10.0
RW-21	5141.9	22.9	8.9	10.0	4.0	9.9	10.0
RW-22	5142.0	25.0	9.0	11.8	4.2	10.0	12.0
RW-23	5142.0	23.5	8.5	10.5	4.5	9.5	11.0
RW-24	5143.5	27.5	12.5	11.0	4.0	13.5	11.0
RW-25	5144.5	36.0	17.0	15.0	4.0	18.0	15.0
RW-26	5145.5	33.5	14.5	15.0	4.0	15.5	15.0
RW-27	5146.5	32.5	13.5	15.0	4.0	14.5	15.0
RW-28	5147.3	31.3	11.3	15.5	4.5	12.3	16.0
RW-29	5152.9	33.9	14.9	14.8	4.2	15.9	15.0
RW-30	5140.1	3[illegible]	21.1	10.8	4.2	22.1	1.0
RW-31	5140.2	39.7	25.7	10.0	4.0	26.7	10.0
RW-32	5150.5	16.5	7.5	4.7	4.3	8.5	5.0
RW-33	5150.3	17.8	7.8	5.5	4.5	8.8	6.0
RW-34	5148.2	23.7	8.7	9.8	4.2	10.7	10.0
RW-35	5147.3	18.3	6.3	5.8	4.2	7.3	6.0
RW-36	5146.1	19.6	7.4	8.0	4.0	8.4	8.0
RW-37	5145.5	22.0	8.0	10.0	4.0	9.0	10.0
RW-38	5145.1	24.8	9.8	10.7	4.3	10.8	11.0

NOTES.

1. WELL DESIGNS ARE BASED ON EXISTING SUBSURFACE DATA; SCREEN PLACEMENTS FOR ALL WELLS SHALL BE BASED ON CONDITIONS OBSERVED AT EACH WELL SITE DURING CONSTRUCTION.
2. SEE SHT. C-1 FOR LOCATIONS OF DW AND RW WELLS.
*3. EXIST. DEWATER WELLS 1-6 ARE TO BE REPLACED BY THE CONTRACTOR ACCORDING TO THESE PLANS AND SPECIFICATION. FOR LOCATIONS OF REPLACEMENT WELLS SEE SHEETS C-2 AND C-3

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

	DATE	DESCRIPTION	MADE	APPR
P	8-5-81	Added to Schedule & Note #3		
1	8-1980	REVISED IN ACCORDANCE WITH AM. NO. 0001		

REVISIONS

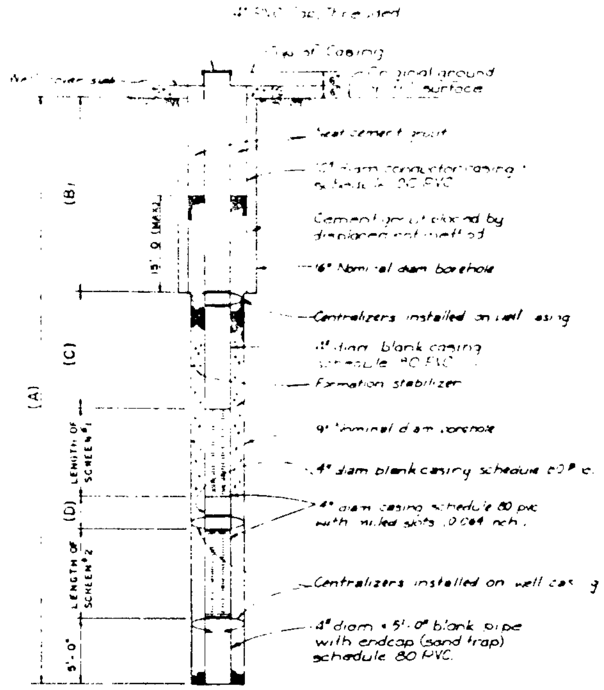
PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
DEWATER AND RECHARGE WELLS
DETAILS

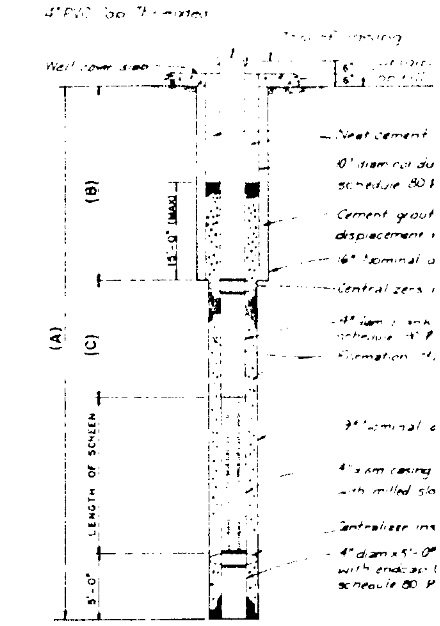
SAFETY PAYS



DEWATERING WELLS - DENVER SANDS

DW-36 THROUGH DW-38 & DW-47 THROUGH DW-48

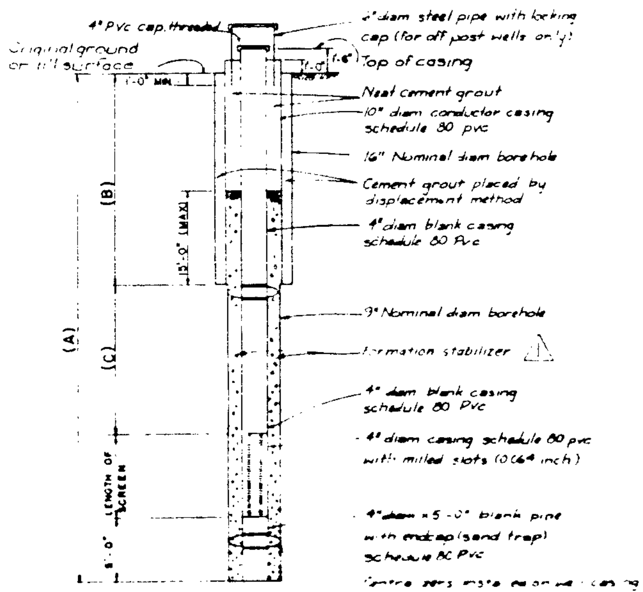
NOT TO SCALE



DEWATERING WELLS - DENVER SANDS

DW-39 THROUGH DW-46 & DW-49 THROUGH DW-54

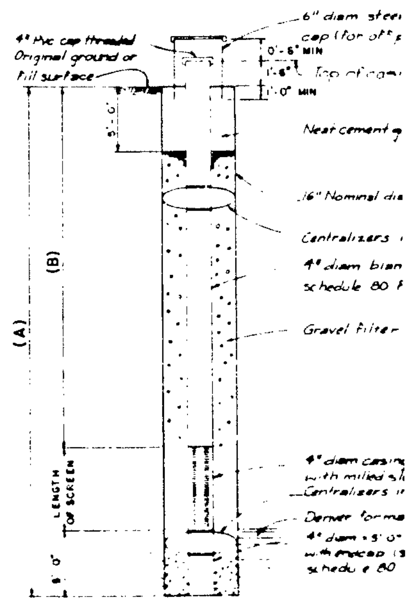
NOT TO SCALE



MONITORING WELLS

DENVER SANDS

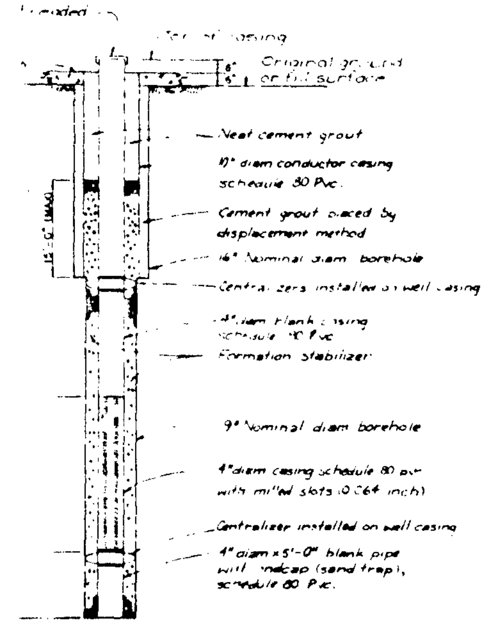
NOT TO SCALE



MONITORING WELLS

ALLUVIUM

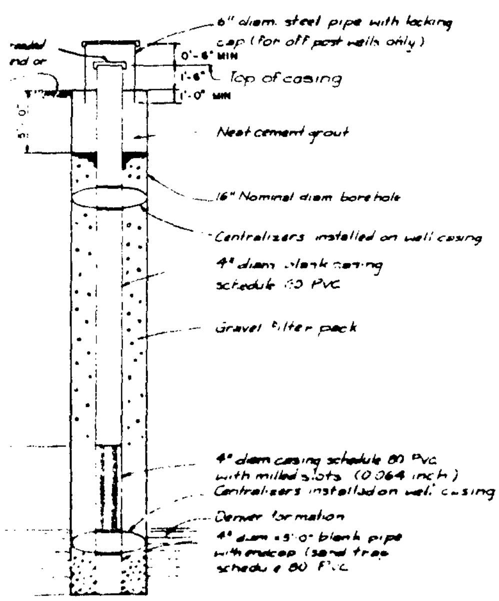
NOT TO SCALE



WELLS - DENVER SANDS

DW-46 & DW-49 THROUGH DW-54

NOT TO SCALE



MONITORING WELLS

ALLUVIUM

NOT TO SCALE

DENVER SANDS DEWATERING WELLS AND DENVER SANDS AND ALLUVIUM MONITORING WELLS DIMENSION SCHEDULE

WELL NUMBER	TOP OF CASING ELEVATION	A (FT.)	B (FT.)	C (FT.)	D (FT.)	RISER LENGTH (FT.)	SCREEN #1 LENGTH (FT.)	SCREEN #2 LENGTH (FT.)	BOTTOM OF WELL ELEVATION
DW-36	5148.7	110.7	47.7	5.5	5.0	[illegible]	10.0	20.0	5038.0
DW-37	5146.5	50.5	5.0	0.5	16.7	[illegible]	10.0	5.0	5086.0
DW-38	5147.9	60.9	25.9	2.5	8.0	28.9	15.0	5.0	5084.0
DW-39	5149.0	54.0	25.5	5.5	—	32.0	20.0	—	5092.0
DW-40	5153.6	57.6	30.1	2.5	—	33.6	20.0	—	5095.0
DW-41	5155.0	58.5	31.0	2.5	—	39.5	20.0	—	5095.5
DW-42	5156.0	66.0	42.5	3.5	—	47.0	15.0	—	5090.0
DW-43	5154.0	59.0	36.5	2.5	—	40.0	15.0	—	5095.0
DW-44	5154.6	58.6	30.1	5.5	—	35.6	10.0	—	5096.0
DW-45	5151.6	61.6	30.1	5.5	—	42.6	15.0	—	5090.0
DW-46	5150.2	59.2	35.7	7.5	—	44.2	10.0	—	5091.0
DW-47	5142.0	90.9	40.4	10.5	20.0	51.9	5.0	10.0	5051.0
DW-48	5142.5	91.5	38.0	15.5	20.0	52.5	5.0	10.0	5050.0
DW-49	5142.6	65.6	15.1	0.5	—	24.6	25.0	—	5076.0
DW-50	5143.3	67.3	39.0	2.5	—	38.3	25.0	—	5075.0
DW-51	5147.6	69.6	38.0	5.5	—	45.6	20.0	—	5077.0
DW-52	5147.5	70.5	43.0	12.5	—	56.5	10.0	—	5077.0
DW-53	5161.6	81.6	40.1	8.5	—	57.8	20.0	—	5080.0
DW-54	5175.0	95.0	60.9	21.5	—	70.0	20.0	—	5080.0
M-1	5137.5	27.0	12.0	—	—	13.5	10.0	—	5110.0
M-2	5141.5	28.0	13.0	—	—	16.5	10.0	—	5112.0
M-3	5142.5	25.5	15.0	—	—	16.5	5.0	—	5117.0
M-4	5143.5	23.0	13.0	—	—	16.5	5.0	—	5120.0
M-5	5141.5	21.0	11.0	—	—	12.5	5.0	—	5119.0
M-6	5141.5	25.5	9.0	—	—	10.5	10.0	—	5116.0
M-7	5140.5	24.0	9.0	—	—	10.5	10.0	—	5115.0
M-8	5140.5	29.0	9.0	—	—	10.5	15.0	—	5110.0
M-9	5144.5	31.0	16.0	—	—	17.5	10.0	—	5112.0
M-10	5144.5	23.0	13.0	—	—	14.5	5.0	—	5122.0
M-11A	5140.5	108.0	82.0	1.0	1.0	84.5	20.0	—	5030.0
M-11B	5140.5	92.0	71.0	1.0	—	73.5	5.0	—	5046.0
M-12	5146.5	30.0	19.0	1.0	—	21.5	5.0	—	5115.0
M-13	5152.5	37.0	26.0	1.0	—	28.5	5.0	—	5115.0
M-14	5153.5	39.0	28.0	1.0	—	30.5	5.0	—	5113.0
M-15A	5153.5	97.0	71.0	1.0	—	73.5	20.0	—	5056.0
M-15B	5152.5	57.0	41.0	1.0	—	43.5	10.0	—	5096.0
M-16	5151.5	23.0	13.0	—	—	14.5	5.0	—	5127.0
M-17	5143.5	17.0	7.0	—	—	8.5	5.0	—	5126.0
M-18A	5141.5	135.0	119.0	1.0	—	121.5	10.0	—	5005.0
M-18B	5141.5	65.0	49.0	1.0	—	51.5	10.0	—	5075.0
M-19	5141.5	31.0	16.0	—	—	17.5	10.0	—	5108.0
M-20A	5144.5	65.0	54.0	1.0	—	56.5	5.0	—	5078.0
M-20B	5144.5	98.0	87.0	1.0	—	89.5	5.0	—	5046.0
M-21	5140.5	28.0	13.0	—	—	14.5	10.0	—	5115.0
M-22	5161.5	20.0	10.0	—	—	11.5	5.0	—	5130.0
M-23	5140.5	28.0	8.0	—	—	9.5	5.0	—	5120.0
M-24	5153.5	21.0	12.0	—	—	13.5	10.0	—	5125.0
M-25	5144.5	29.0	14.0	—	—	15.5	5.0	—	5115.0
M-26	5147.5*	29.0	14.0	—	—	15.5	10.0	—	5117.0
M-27	5142.5	21.0	11.0	—	—	12.5	5.0	—	5120.0
M-28	5149.5	37.0	17.0	—	—	18.5	10.0	—	5110.5
M-29	5142.5	31.0	16.0	—	—	17.5	10.0	—	5110.0
M-30	5144.5	28.0	11.0	—	—	12.5	10.0	—	5117.0
M-31	5153.5	21.0	11.0	—	—	12.5	5.0	—	5131.0
M-32	5147.5	28.0	18.0	—	—	19.5	5.0	—	5118.0
M-33	5144.5	35.0	20.0	—	—	21.5	10.0	—	5108.0
M-34	5142.5	28.0	14.0	—	—	15.5	10.0	—	5112.0
M-35	5146.5	27.0	12.0	—	—	13.5	10.0	—	5118.0
M-36	5148.5	22.0	7.0	—	—	8.5	10.0	—	5125.0
M-37	5150.5	24.0	14.0	—	—	15.5	5.0	—	5133.0
M-38A	5150.5	100.0	84.0	1.0	—	86.5	10.0	—	5050.0
M-38B	5150.5	250.0	234.0	1.0	—	236.5	10.0	—	4900.0
M-39	5162.5	28.0	14.0	—	—	15.5	10.0	—	5132.0
M-40A	5129.5	43.0	28.0	—	—	29.5	10.0	—	5086.0
M-40B	5129.5	100.0	84.0	1.0	—	86.5	10.0	—	5023.0
M-40C	5129.5	250.0	234.0	1.0	—	236.5	10.0	—	4873.0
M-41	5136.5	35.0	20.0	—	—	21.5	10.0	—	5100.0
M-42A	5108.5	100.0	84.0	1.0	—	86.5	10.0	—	5007.0
M-42B	5108.5	250.0	234.0	1.0	—	236.5	10.0	—	4857.0
M-43	5119.5	49.0	21.0	—	—	24.5	20.0	—	5070.0
M-44	5127.5	36.0	11.0	—	—	12.5	20.0	—	5090.0
M-45A	5125.5	100.0	84.0	1.0	—	86.5	10.0	—	5025.0
M-45B	5125.5	250.0	234.0	1.0	—	236.5	10.0	—	4875.0
M-46	5128.5	18.0	3.0	—	—	4.5	15.0	—	5110.0
M-47	5140.5	37.0	27.0	—	—	28.5	5.0	—	5110.0
M-48	5140.5	42.0	32.0	—	—	33.5	5.0	—	5105.0
M-49	5144.5	43.0	28.0	—	—	29.5	10.0	—	5100.0
M-50	5140.5	24.0	9.0	—	—	10.5	10.0	—	5115.0
M-51	5142.5	31.0	16.0	—	—	17.5	10.0	—	5110.0

NOT IN CONTRACT

NOTES:

1. WELL DESIGNS ARE BASED ON EXISTING SUBSURFACE DATA; SCREEN PLACEMENT FOR ALL WELLS SHALL BE BASED ON CONDITIONS OBSERVED AT EACH WELL SITE DURING CONSTRUCTION RESULTS OF ELECTRIC & GAMMA LOGGING SHALL BE USED IN CONJUNCTION WITH THESE OBSERVATION FOR THE PLACEMENT OF SCREENS IN DENVER SAND WELLS.
2. SEE SHT. C-1 FOR LOCATIONS OF DW-WELLS AND SHT. C-?? FOR LOCATIONS OF M WELLS.

THIS DRAWING HAS BEEN REDUCED TO HALF ... THE ORIGINAL SCALE.

8/3/90	AM #0001 GENERAL REVISIONS		CJB
DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
DENVER SAND DEWATER WELLS AND MONITORING WELLS DETAILS

JUNE 1990

71-07-16

PUMP SCHEDULE											
IDENT. NO.	CAPACITY GPM	HEAD FT H_2O	ELECTRICAL			TYPE	A ELEVATION	B (FT)	C (FT)	D (FT)	REMARKS
			VOLTAGE	PHASE	HERTZ						
DW-1 (321)	4	174	230	1	60	SUBMERSIBLE	5148.1	9.4	13.8	18.1	NOTE 1, NOTE 2
DW-2 (320)	5.7	187				SUBMERSIBLE	5148.3	7.0	12.3	15.3	NOTE 1.
DW-3 (319)	9	201				SUBMERSIBLE	5148.8	10.5	15.1	19.3	NOTE 1.
DW-4 (318)	11	274				SUBMERSIBLE	5156.2	16.8	21.3	26.7	NOTE 1.
DW-5 (317)	12.8	275				SUBMERSIBLE	5156.9	17.7	22.3	31.0	NOTE 1.
DW-6 (316)	14.9	276				SUBMERSIBLE	5157.3	18.3	23.1	29.3	NOTE 1.
DW-7	16.2	276				SUBMERSIBLE	5156.6	17.4	23.6	27.6	
DW-8	16.5	271				SUBMERSIBLE	5155.7	16.4	22.7	26.7	
DW-9	17.9	269				SUBMERSIBLE	5154.3	14.8	21.3	28.3	
DW-10	14.8	261				SUBMERSIBLE	5152.7	13.0	18.7	29.7	
DW-11	14.8	254				SUBMERSIBLE	5152.5	12.7	18.5	26.0	
DW-12	20	257				SUBMERSIBLE	5153.7	13.7	19.7	27.2	
DW-13	23	257				SUBMERSIBLE	5152.0	11.9	18.5	28.0	
DW-14	21.9	262				SUBMERSIBLE	5148.1	8.9	17.1	28.6	
DW-15	20.8	337				SUBMERSIBLE	5147.7	7.5	15.7	27.2	
DW-16	20.1	336				SUBMERSIBLE	5145.8	5.6	13.8	24.3	
DW-17	28	343				SUBMERSIBLE	5144.9	4.8	13.4	21.9	
DW-18	26.2	342				SUBMERSIBLE	5146.1	5.0	13.6	24.5	
DW-19	25.7	336				SUBMERSIBLE	5144.8	4.8	13.3	25.[illegible]	
DW-20	23.9	331				SUBMERSIBLE	5143.5	3.7	12.0	26.5	
DW-21	15.3	318				SUBMERSIBLE	5142.2	2.7	10.7	29.2	
DW-22	13.8	313				SUBMERSIBLE	5142.0	2.6	10.5	30.5	
DW-23	18.6	312				SUBMERSIBLE	5142.0	2.9	11.0	28.0	
DW-24	18.9	[illegible]				SUBMERSIBLE	5143.4	4.4	12.4	[illegible]	
DW-25	19.1	301				SUBMERSIBLE	5144.0	4.9	13.0	24.5	
DW-26	10.6	296				SUBMERSIBLE	5147.8	8.6	16.3	26.8	
DW-27	10.0	298				SUBMERSIBLE	5148.3	9.1	16.3	25.8	
DW-28	9.0	301				SUBMERSIBLE	5148.7	9.4	16.2	23.7	
DW-29	6.0	301				SUBMERSIBLE	5148.8	10.4	16.3	21.8	
DW-30	1	177				SUBMERSIBLE	5166.3	22.0	24.8	28.8	
DW-31	2	177				SUBMERSIBLE	5160.8	16.5	18.8	23.8	
DW-32	3	176				SUBMERSIBLE	5156.4	13.2	17.9	23.4	
DW-33	5.5	176				SUBMERSIBLE	5153.6	11.2	16.1	21.6	
DW-34	4	170				SUBMERSIBLE	5152.0	11.0	17.5	25.5	
DW-35	4	163				SUBMERSIBLE	3148.8	9.4	15.8	21.3	
DW-36	5	220				SUBMERSIBLE	5140.2	56.2	61.2	108.2	
DW-37	2	205				SUBMERSIBLE	5146.0	21.0	26.0	58.0	
DW-38	2	193				SUBMERSIBLE	5147.4	21.4	26.4	50.4	
DW-39	2	173				SUBMERSIBLE	5148.5	26.5	31.5	54.5	
DW-40	1	141				SUBMERSIBLE	5153.1	26.1	31.1	56.1	
DW-41	1	107				SUBMERSIBLE	5154.5	42.5	47.5	57.0	
DW-42	1	70				SUBMERSIBLE	5155.5	48.5	53.5	64.5	
DW-43	1	70				SUBMERSIBLE	5154.5	42.5	47.5	57:5	
DW-44	1	72				SUBMERSIBLE	5154.1	42.1	47.1	58.1	
DW-45		73				SUBMERSIBLE	5151.1	37.1	42.1	60.1	
DW-46	1	74				SUBMERSIBLE	5140.7	36.7	41.7	56.7	
DW-47	1	312				SUBMERSIBLE	5142.4	36.4	41.4	88.7	
DW-48	1	312				SUBMERSIBLE	5142.0	37.0	42.0	90.0	
DW-49	2	305				SUBMERSIBLE	5142.1	26.1	31.1	84.1	
DW-50	2	305				SUBMERSIBLE	5142.8	25.8	30.8	85.8	
DW-51	2	303				SUBMERSIBLE	5146.9	29.9	34.9	67.9	
DW-52	1	315				SUBMERSIBLE	5148.0	44.0	49.0	88.0	
DW-53	2	305				SUBMERSIBLE	5161.1	44.1	49.1	80.1	
DW-54	2	305	230	1	60	SUBMERSIBLE	5175.4	59.4	64.4	93.4	NOTE 2
P-1	290	140	460	3	60	VERTICAL TURBINE	NA	NA	NA	NA	INFLUENT WET WELL
P-2	290	140	460	3	60	VERTICAL TURBINE	NA	NA	NA	NA	INFLUENT WET WELL
P-3	290	140	460	3	60	VERTICAL TURBINE	NA	NA	NA	NA	INFL[illegible]T WET WELL
P-4	487	86	460	3	60	VERTICAL TURBINE	NA	NA	NA	NA	EFFLUENT WET WELL
P-5	487	86	460	3	60	VERTICAL TURBINE	NA	NA	NA	NA	EFFLUENT WET WELL

NOTES:
1. THESE ARE EXISTING WELLS. ALL PUMPS, CONTROLS, VALVES, PIPING, ETC., SHALL BE REMOVED AND REPLACED IN ACCORDANCE WITH THESE PLANS AND SPECIFICATIONS.
2. SEE SHEET C-72 FOR LOCATIONS OF ELEVATIONS AND DIMENSIONS.
3. THESE ARE EXISTING RECHARGE WELLS. ALL CONTROLS, VALVES, PIPING, ETC. SHALL BE REMOVED & REPLACED IN ACCORDANCE WITH THESE PLANS & SPECIFICATIONS

EXISTING	
IDENT NO.	A
DW-1 (321)	5144
DW 2 (320)	5142
DW 3 (319)	5145
DW-4 (318)	515
DW-5 (317)	5152
DW-6 (316)	5153

NOTE: ELEVATIONS ARE

R	
IDENT. NO.	E ELEVAT
RW-1 *	5145
RW-2 *	5145
RW-3 *	5146.
RW-4 *	5150
RW-5 *	5153
RW-6 *	5154
RW-7 *	5154
RW-8 *	5153.
RW-9 *	5159
RW-10 *	5152.
RW-11 *	5152
RW-12 *	5152
RW-13	5151
RW-14	5145.
RW-15	5145.
RW-16	5145
RW-17	5144
RW-18	5141
RW-19	5142.

* SEE NOTE 3

RKS

EXISTING WELL ELEVATIONS			
IDENT. NO.	A'	IDENT. NO.	E'
DW-1 (321)	5144.5	RW-1 (322)	5141.0
DW-2 (320)	5142.5	RW-2 (323)	5141.0
DW-3 (319)	5146.5	RW-3 (324)	5142.0
DW-4 (318)	5151.5	RW-4 (325)	5145.0
DW-5 (317)	5152.5	RW-5 (326)	5147.0
DW-6 (316)	5153.5	RW-6 (327)	5148.0
		RW-7 (328)	5149.0
		RW-8 (329)	5148.0
		RW-9 (330)	5148.0
		RW-10 (331)	5148.0
		RW-11 (332)	5148.0
		RW-12 (333)	5148.0

NOTE: ELEVATIONS ARE TOP OF EXISTING WELL CASINGS.

1

RECHARGE WELL ELEVATIONS					
IDENT. NO.	E ELEVATION	F (FT)	IDENT. NO.	E ELEVATION	F (FT)
RW-1 *	5146.1	9.6	RW-20	5142.0	4.5
RW-2 *	5146.6	10.2	RW-21	5141.4	3.7
RW-3 *	5146.8	11.5	CW-22	5141.5	3.6
RW-4 *	5150.2	15.1	RW-23	5141.5	3.6
RW-5 *	5153.1	17.7	RW-24	5143.0	5.4
RW-6 *	5154.1	18.4	RW-25	5144.0	6.4
RW-7 *	5154.3	18.8	RW-26	5146.0	7.4
RW-8 *	5153.6	18.8	RW-27	5146.0	8.4
RW-9 *	5150.9	17.2	RW-28	5146.8	9.2
RW-10 *	5152.7	16.9	RW-29	5151.7	14.2
RW-11 *	5152.6	16.7	RW-30	5158.3	21.4
RW-12 *	5152.4	18.4	RW-31	5168.7	30.7
RW-13	5151.2	14.5	RW-32	5150.0	7.9
RW-14	5146.8	8.9	RW-33	5148.8	7.8
RW-15	5146.6	8.5	RW-34	5147.7	6.8
RW-16	5146.2	8.2	RW-35	5146.8	6.4
RW-17	5144.2	7.2	RW-36	5146.6	7.1
RW-18	5141.8	4.5	RW-37	5145.0	6.8
RW-19	5142.0	4.8	RW-38	5144.6	7.8

* SEE NOTE 3

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

	DATE	DESCRIPTION	MADE	APPR'D
P-11	9-5-81	REVISED PUMP SCHEDULE		COB
1	8-13-80	REVISED IN ACCORDANCE WITH AM. NO. 0001		COB

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

DESIGNED BY DDL
DRAWN BY TWS
CHECKED BY SWD

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
PUMP SCHEDULES AND
WELL ELEVATIONS

DATE: JUNE 1980

SCALE AS SHOWN

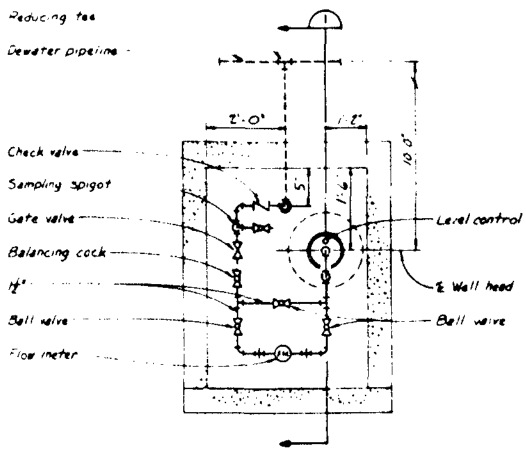
SPEC. NO. DACA45-80-B-0161

DRAWING NUMBER 71-07-16

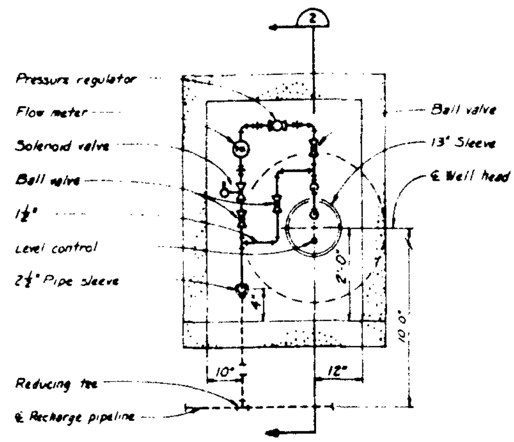
SHEET C-73

THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 81 C0054 MODIFICATION NO. P00011

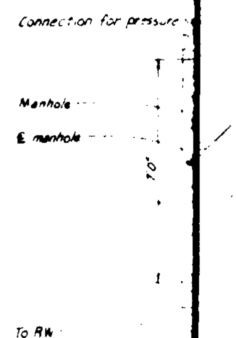
2



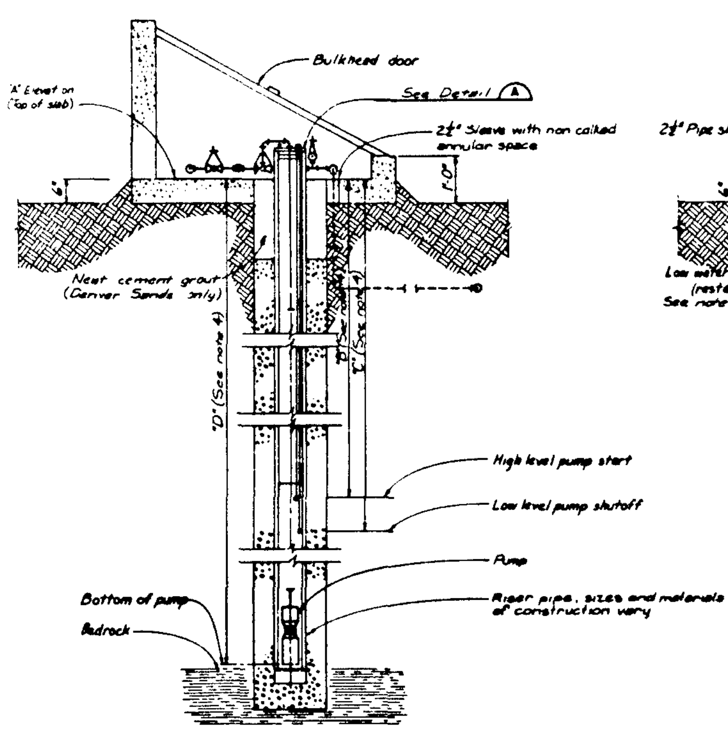
DEWATER WELL PLAN
No scale
Cover removed for clarity
(Typical)



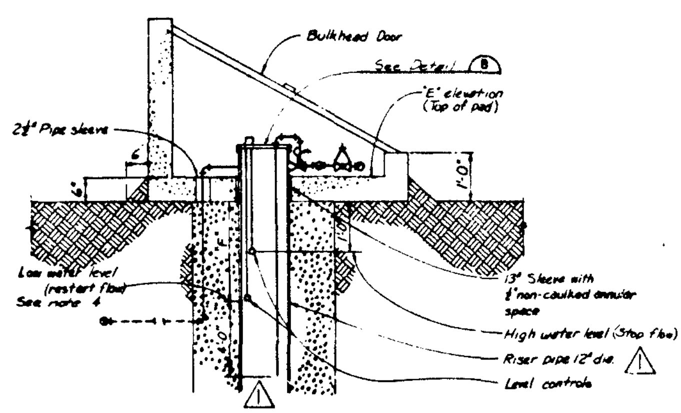
RECHARGE WELL PLAN
No scale
Cover removed for clarity
(Typical)



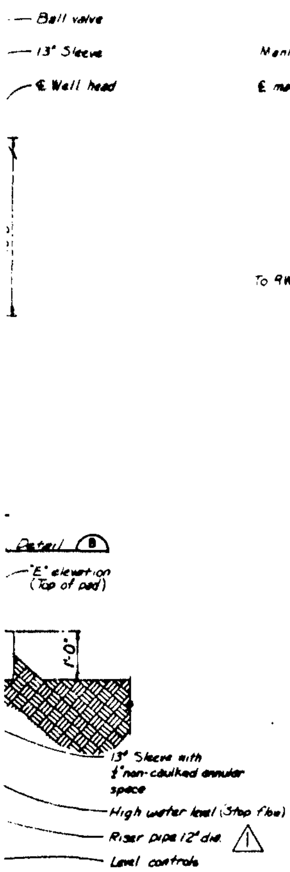
OVE

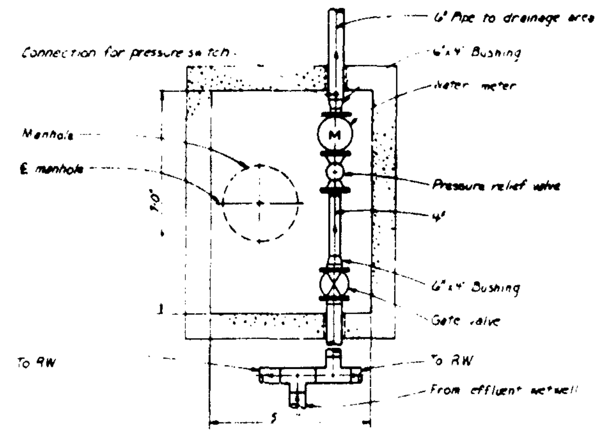


SECTION 1
No scale

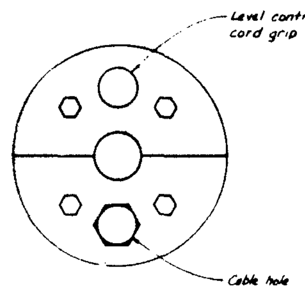


SECTION 2
No scale





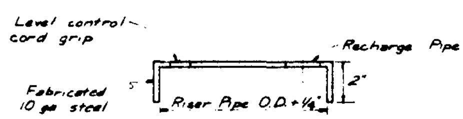
OVERFLOW VALVE PIT PLAN
No scale
Cover removed for clarity



DEWATER WELL HEAD DETAIL (A)
No scale

NOTES:

1. SEE SHEETS C-2, C-3, AND C-4 FOR CONTINUATION OF DEWATER, RECHARGE, AND TREATED EFFLUENT OVERFLOW LINES.
2. SEE SHEET S-4 FOR DETAILS OF WELL COVER AND OVERFLOW VALVE PIT STRUCTURES.
3. SEE SHEETS C-70 AND C-71 FOR WELL CONSTRUCTION DETAILS.
4. SEE SHEET C-73 FOR PUMP AND LEVEL CONTROL INFORMATION.
5. SEE SHEET C-37 FOR TYPICAL WELL MOUNDING DETAILS.



RECHARGE WELL HEAD DETAIL (B)
No Scale

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

8-19-80	AM #000 GENERAL REVISIONS		COB
DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
WELL AND VALVE PIT PIPING DETAILS

Designed by: DDL
Drawn by: TWS
Checked by: SWP

JUNE 14,

DACA45-80-R-0161

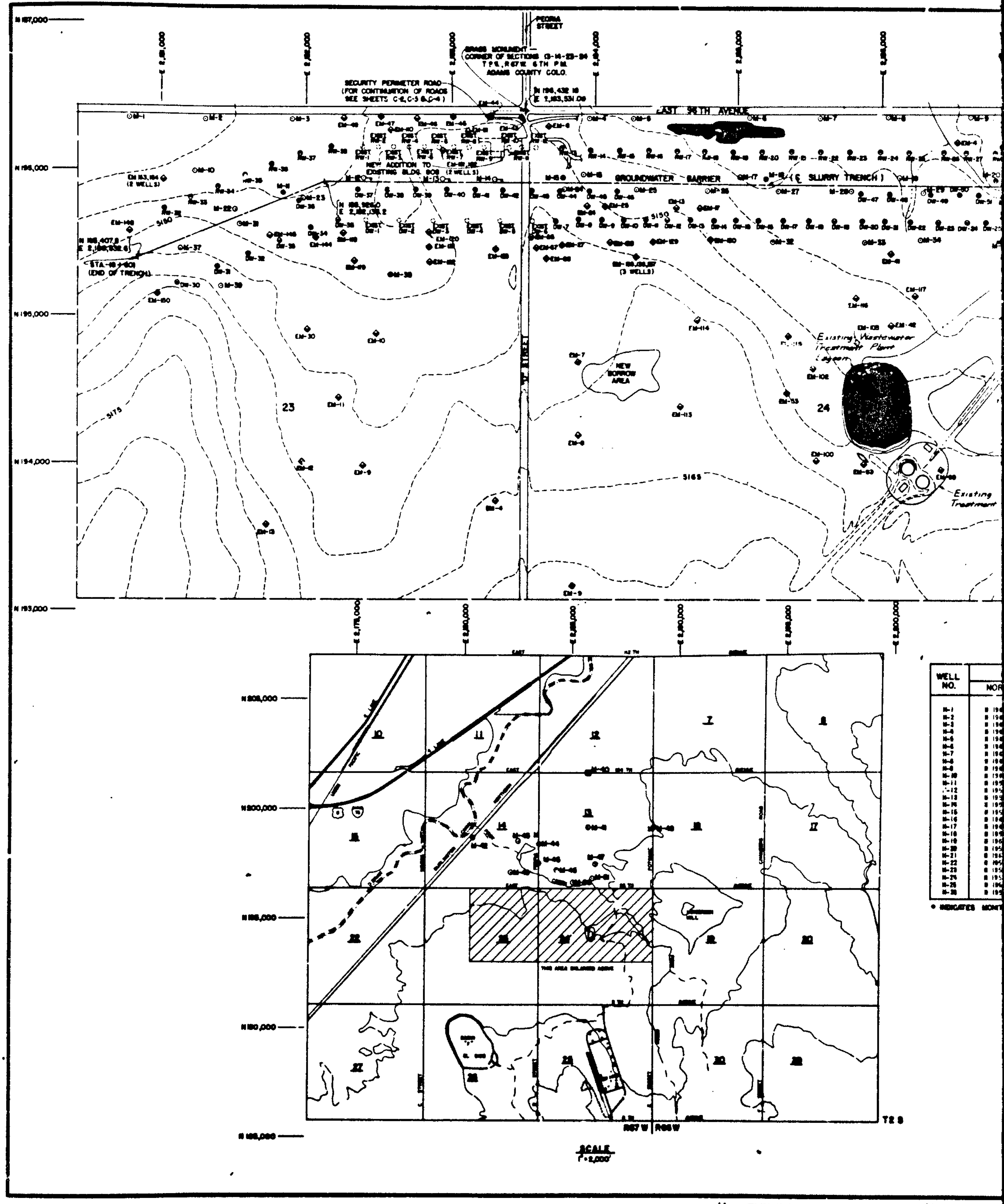
71-07-16

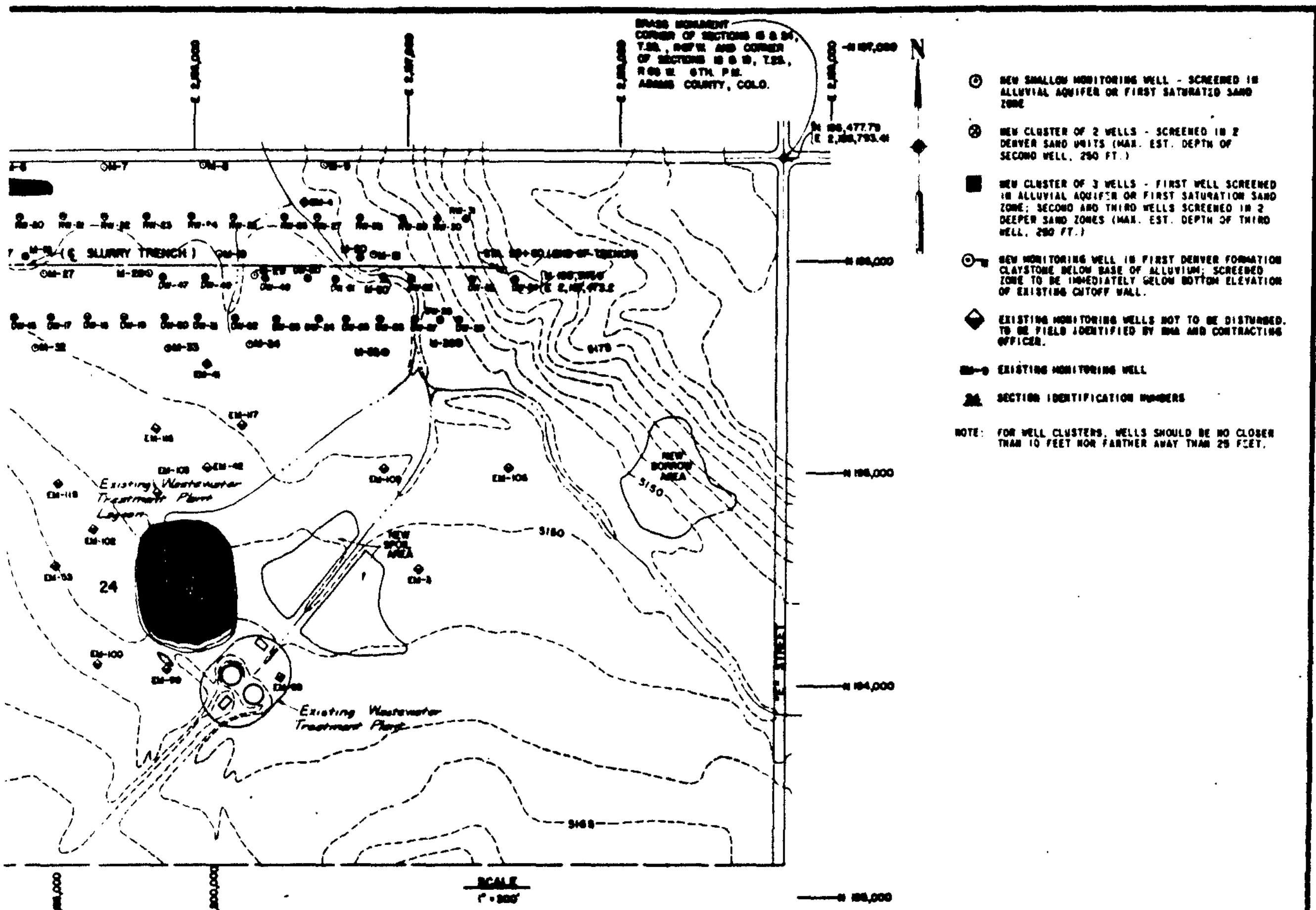
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 CO MODIFICAT. 1 NO.

SAFETY PAYS

THINK VALUE ENGINEERING — $$

PLATE 78A


PEORIA STREET
BRASS MONUMENT — CORNER OF SECTIONS 13-14-23-24 T2S, R67W 6TH P.M. ADAMS COUNTY COLO.
SECURITY PERIMETER ROAD (FOR CONTINUATION OF ROADS SEE SHEETS C-2, C-3 & C-4)
N 196,432.18
E 2,183,531.09
EAST 96TH AVENUE
NEW ADDITION TO EXISTING BLDG. 808 (2 WELLS)
GROUNDWATER BARRIER
(℄ SLURRY TRENCH)
N 195,965.0
E 2,182,136.2
N 195,407.8
E 2,180,932.6
STA. 48+60 (END OF TRENCH)
NEW BORROW AREA
Existing Wastewater Treatment Plant Lagoon
Existing Treatment
23
24
5150
5165
5175
N 197,000
N 196,000
N 195,000
N 194,000
N 193,000
N 200,000
N 190,000
N 185,000
T2S
R67W | R66W
SCALE
1" = 2,000'
WELL NO.
NOR
INDICATES MONI



⊙ NEW SHALLOW MONITORING WELL - SCREENED IN ALLUVIAL AQUIFER OR FIRST SATURATED SAND ZONE

⊗ NEW CLUSTER OF 2 WELLS - SCREENED IN 2 DENVER SAND UNITS (MAX. EST. DEPTH OF SECOND WELL, 290 FT.)

■ NEW CLUSTER OF 3 WELLS - FIRST WELL SCREENED IN ALLUVIAL AQUIFER OR FIRST SATURATION SAND ZONE; SECOND AND THIRD WELLS SCREENED IN 2 DEEPER SAND ZONES (MAX. EST. DEPTH OF THIRD WELL, 290 FT.)

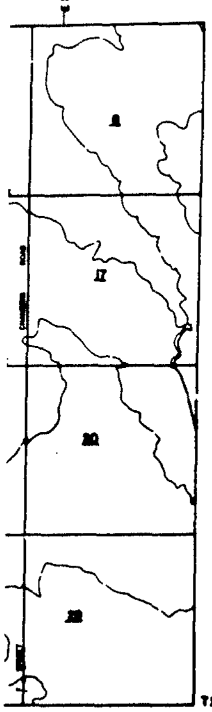
NEW MONITORING WELL IN FIRST DENVER FORMATION CLAYSTONE BELOW BASE OF ALLUVIUM; SCREENED ZONE TO BE IMMEDIATELY BELOW BOTTOM ELEVATION OF EXISTING CUTOFF WALL.

◆ EXISTING MONITORING WELLS NOT TO BE DISTURBED. TO BE FIELD IDENTIFIED BY RMA AND CONTRACTING OFFICER.

EXISTING MONITORING WELL

24 SECTION IDENTIFICATION NUMBERS

NOTE: FOR WELL CLUSTERS, WELLS SHOULD BE NO CLOSER THAN 10 FEET NOR FARTHER AWAY THAN 25 FEET.



NEW MONITORING WELL LOCATIONS

WELL NO.	COORDINATES NORTH	COORDINATES EAST	WELL NO.	COORDINATES NORTH	COORDINATES EAST
N-1	N 196,375	E 2,180,775	N-27	N 196,[illegible]	E 2,185,[illegible]
N-2	N 196,375	E 2,181,[illegible]	N-28	N 196,[illegible]	E 2,186,[illegible]
N-3	N 196,375	E 2,181,900	N-29	N 195,[illegible]	E 2,186,[illegible]
N-4	N 196,375	E 2,183,0[illegible]	N-30	N 196,[illegible]	E 2,186,[illegible]
N-5	N 196,375	E 2,18[illegible]	N-31	N 196,[illegible]	E 2,181,[illegible]
N-6	N 196,[illegible]	E 2,18[illegible]	N-32	N 196,[illegible]	E 2,186,[illegible]
N-7	N 196,375	E 2,18[illegible],575	N-33	N 196,[illegible]	E 2,186,[illegible]
N-8	N 196,375	E 2,18[illegible]	N-34	N 196,[illegible]	E 2,184,250
N-9	N 196,[illegible]	E 2,18[illegible]	N-35	N 195,540	E 2,186,[illegible]
N-10	N 196,[illegible]	E 2,181,225	N-36	N 196,[illegible]	E 2,187,[illegible]
N-11	N 195,[illegible]	E 2,181,[illegible]	N-37	N 196,[illegible]	E 2,181,125
N-12	N 195,945	E 2,182,415	N-38	N 195,[illegible]	E 2,182,[illegible]
N-13	N 195,[illegible]	E 2,182,[illegible]	N-39	N 195,225	E 2,181,[illegible]
N-14	N 195,965	E 2,183,[illegible]	* N-40	N 201,[illegible]	E 2,185,[illegible]
N-15	N 195,975	E 2,183,700	* N-41	N [illegible]	E 2,185,[illegible]
N-16	N 196,[illegible]	E 2,183,525	* N-42	N [illegible]	E 2,180,[illegible]
N-17	N 196,[illegible]	E 2,18[illegible]	* N-43	N [illegible]	E 2,182,[illegible]
N-18	N 196,[illegible]	E 2,185,[illegible]	* N-44	N [illegible]	E 2,183,[illegible]
N-19	N 196,[illegible]	E 2,18[illegible],125	* N-45	N 197,[illegible]	E 2,183,[illegible]
N-20	N 195,[illegible]	E 2,18[illegible],775	* N-46	N 197,[illegible]	E 2,18[illegible]
N-21	N [illegible]	E 2,18[illegible]	* N-47	N 197,[illegible]	E 2,18[illegible]
N-22	N 195,750	E 2,181,[illegible]	* N-48	N [illegible]	E 2,180,[illegible]
N-23	N 195,[illegible]	E 2,181,975	* N-49	N 197,[illegible]	E 2,182,[illegible]
N-24	N 195,[illegible]	E 2,183,[illegible]	* N-50	N 196,700	E 2,186,[illegible]
N-25	N 196,[illegible]	E 2,18[illegible]	* N-51	N 196,[illegible]	E 2,186,[illegible]
N-26	N 195,[illegible]	E 2,18[illegible]			

* INDICATES MONITORING WELLS WITHIN SMALL SCALE DRAWING NOT IN CONTRACT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPR
8-15-80	REVISED IN ACCORDANCE WITH AM. NO. 0001		

REVISIONS

PREPARED BY BLACK & VEATCH CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
MONITORING WELLS LOCATION PLAN

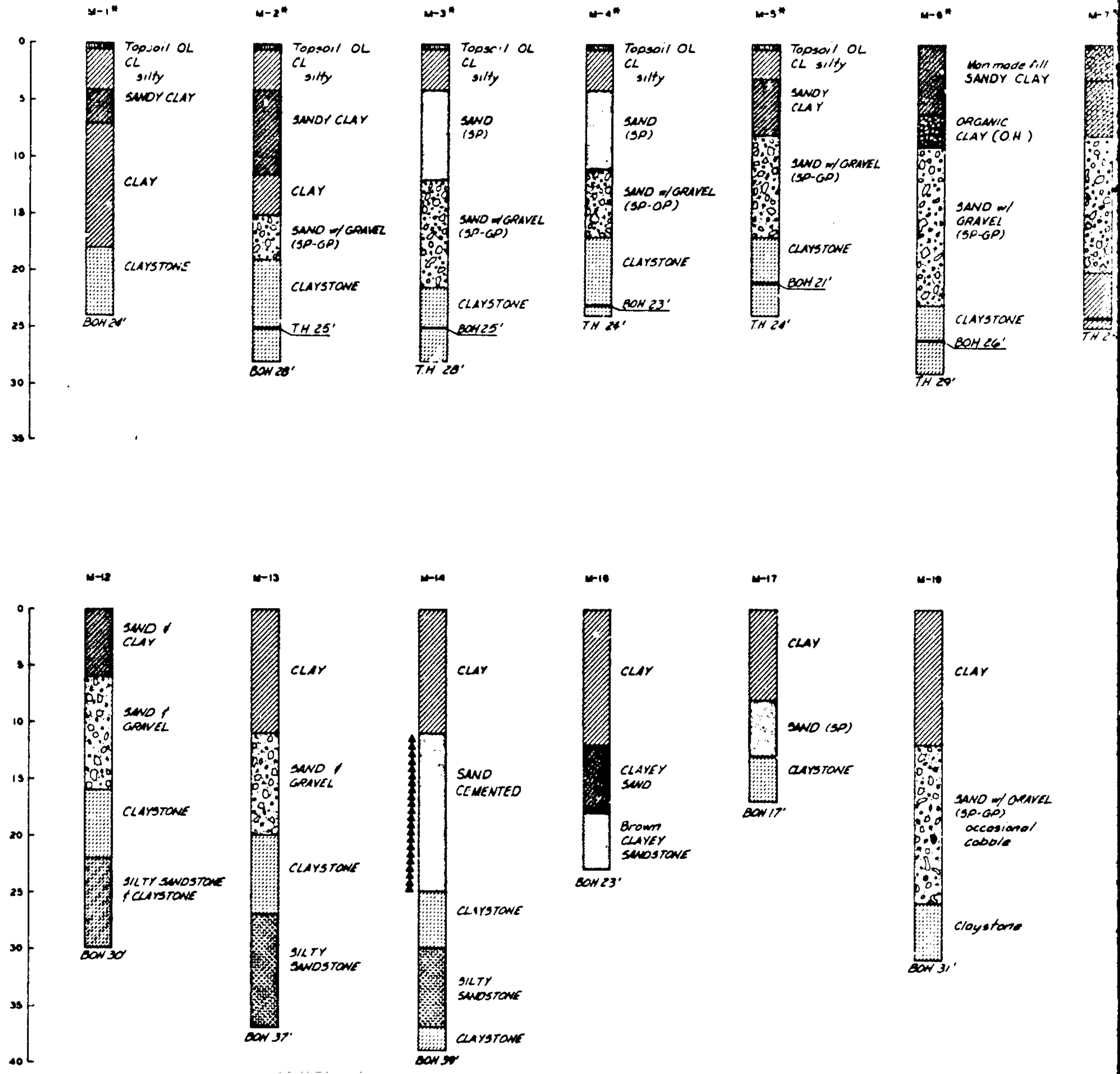
JUNE 1980

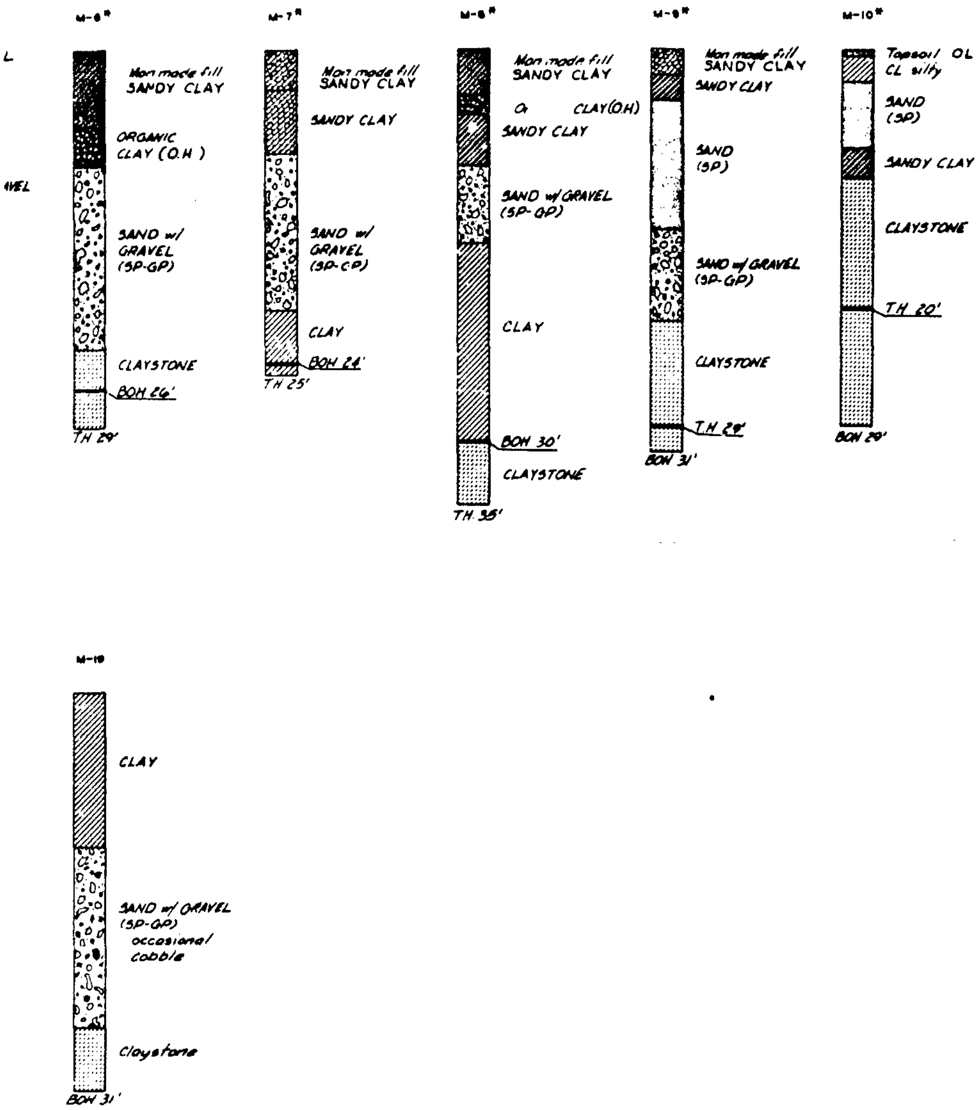
THIS PLAN ACCOMPANIES CONTRACT NO. DACA 45 7 80

71-07-16

SCALE 1" = 300'

SAFETY PAYS


M-1*
Topsoil OL
CL silty
SANDY CLAY
CLAY
CLAYSTONE
BOH 24'
M-2*
Topsoil OL
CL silty
SANDY CLAY
CLAY
SAND w/ GRAVEL (SP-GP)
CLAYSTONE
T.H 25'
BOH 28'
M-3*
CL silty
SAND (SP)
SAND w/ GRAVEL (SP-GP)
CLAYSTONE
BOH 25'
T.H 28'
M-4*
Topsoil OL
CL silty
SAND (SP)
SAND w/ GRAVEL (SP-GP)
CLAYSTONE
BOH 23'
TH 24'
M-5*
Topsoil OL
CL silty
SANDY CLAY
SAND w/ GRAVEL (SP-GP)
CLAYSTONE
BOH 21'
TH 24'
M-6*
SANDY CLAY
ORGANIC CLAY (O.H.)
SAND w/ GRAVEL (SP-GP)
CLAYSTONE
BOH 26'
TH 29'
M-12
SAND & CLAY
SAND & GRAVEL
CLAYSTONE
SILTY SANDSTONE & CLAYSTONE
BOH 30'
M-13
CLAY
SAND & GRAVEL
CLAYSTONE
SILTY SANDSTONE
BOH 37'
M-14
CLAY
SAND CEMENTED
CLAYSTONE
SILTY SANDSTONE
CLAYSTONE
BOH 39'
M-16
CLAY
CLAYEY SAND
Brown CLAYEY SANDSTONE
BOH 23'
M-17
CLAY
SAND (SP)
CLAYSTONE
BOH 17'
M-18
CLAY
SAND w/ GRAVEL (SP-GP) occasional cobble
Claystone
BOH 31'



Note:
* TH drilled and logged by Fox Drilling, Inc

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPR'D

REVISIONS

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
MONITOR WELL BORING LOGS
M-1 THROUGH M-19

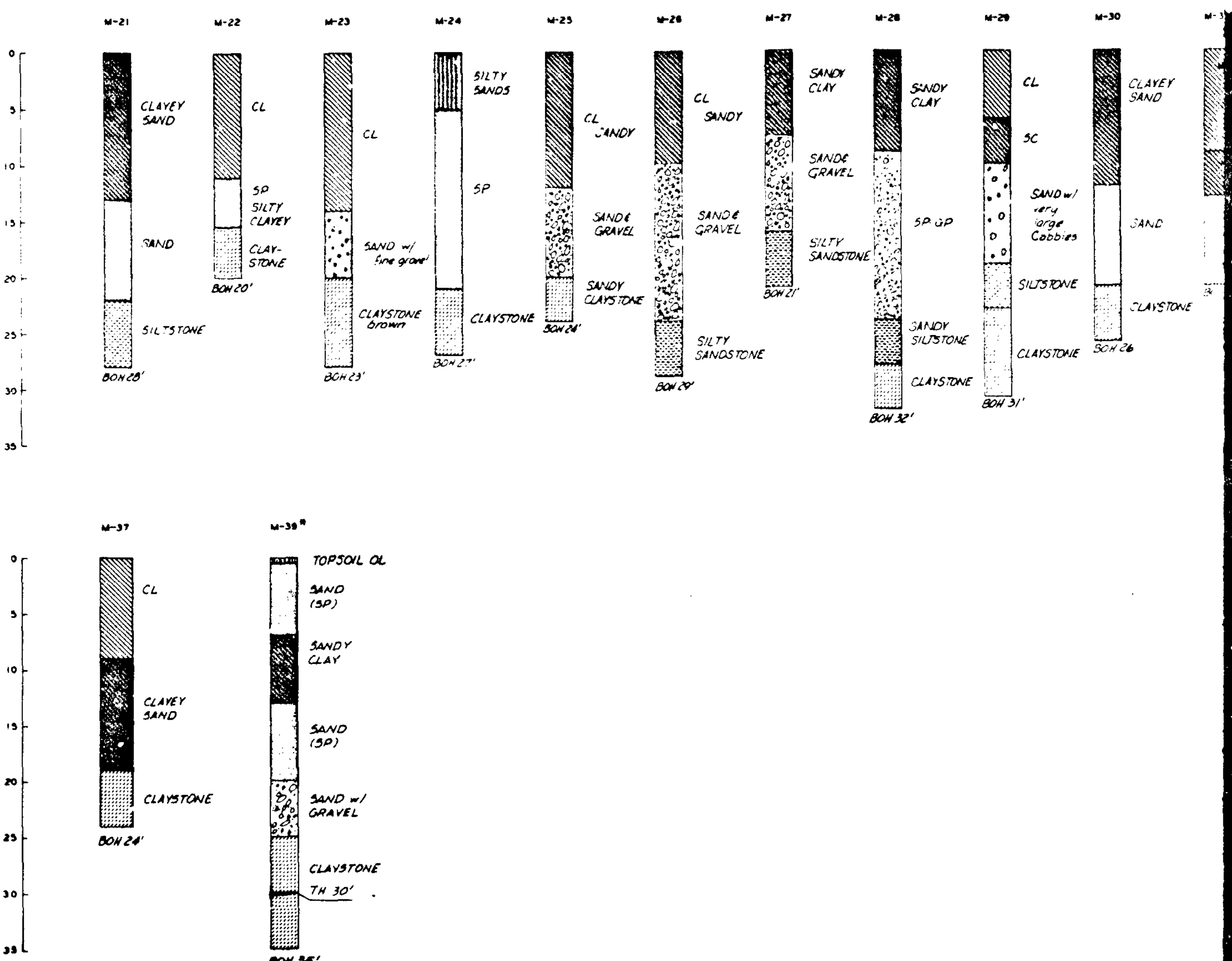
SCALE: AS SHOWN

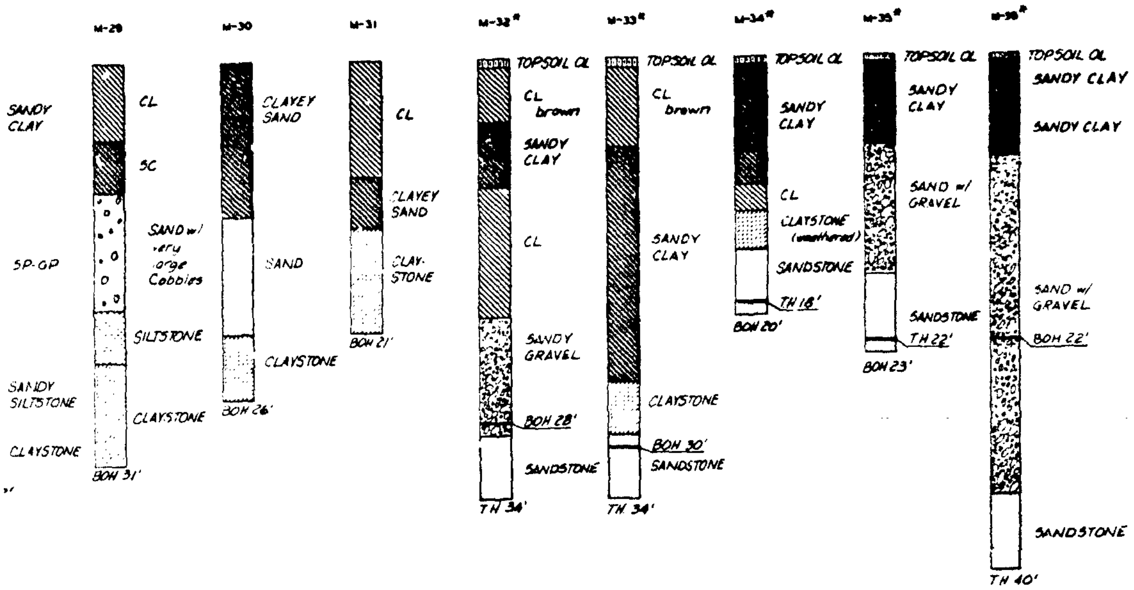
71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO.
MODIFICATION NO.

THINK VALUE ENGINEERING — $$

PLATE 81


M-21
M-22
M-23
M-24
M-25
M-26
M-27
M-28
M-29
M-30
CLAYEY SAND
SAND
SILTSTONE
BOH 28'
CL
SP SILTY CLAYEY
CLAY-STONE
BOH 20'
CL
SAND w/ fine gravel
CLAYSTONE brown
BOH 23'
SILTY SANDS
SP
CLAYSTONE
BOH 27'
CL SANDY
SAND & GRAVEL
SANDY CLAYSTONE
BOH 24'
CL SANDY
SAND & GRAVEL
SILTY SANDSTONE
BOH 29'
SANDY CLAY
SAND & GRAVEL
SILTY SANDSTONE
BOH 21'
SANDY CLAY
SP GP
SANDY SILTSTONE
CLAYSTONE
BOH 32'
CL
SC
SAND w/ very large Cobbles
SILTSTONE
CLAYSTONE
BOH 31'
CLAYEY SAND
SAND
CLAYSTONE
BOH 26
M-37
M-38
CL
CLAYEY SAND
CLAYSTONE
BOH 24'
TOPSOIL OL
SAND (SP)
SANDY CLAY
SAND (SP)
SAND w/ GRAVEL
CLAYSTONE
TH 30'
BOH 35'



Note:
* T.H. drilled and logged by Fox Drilling Inc.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

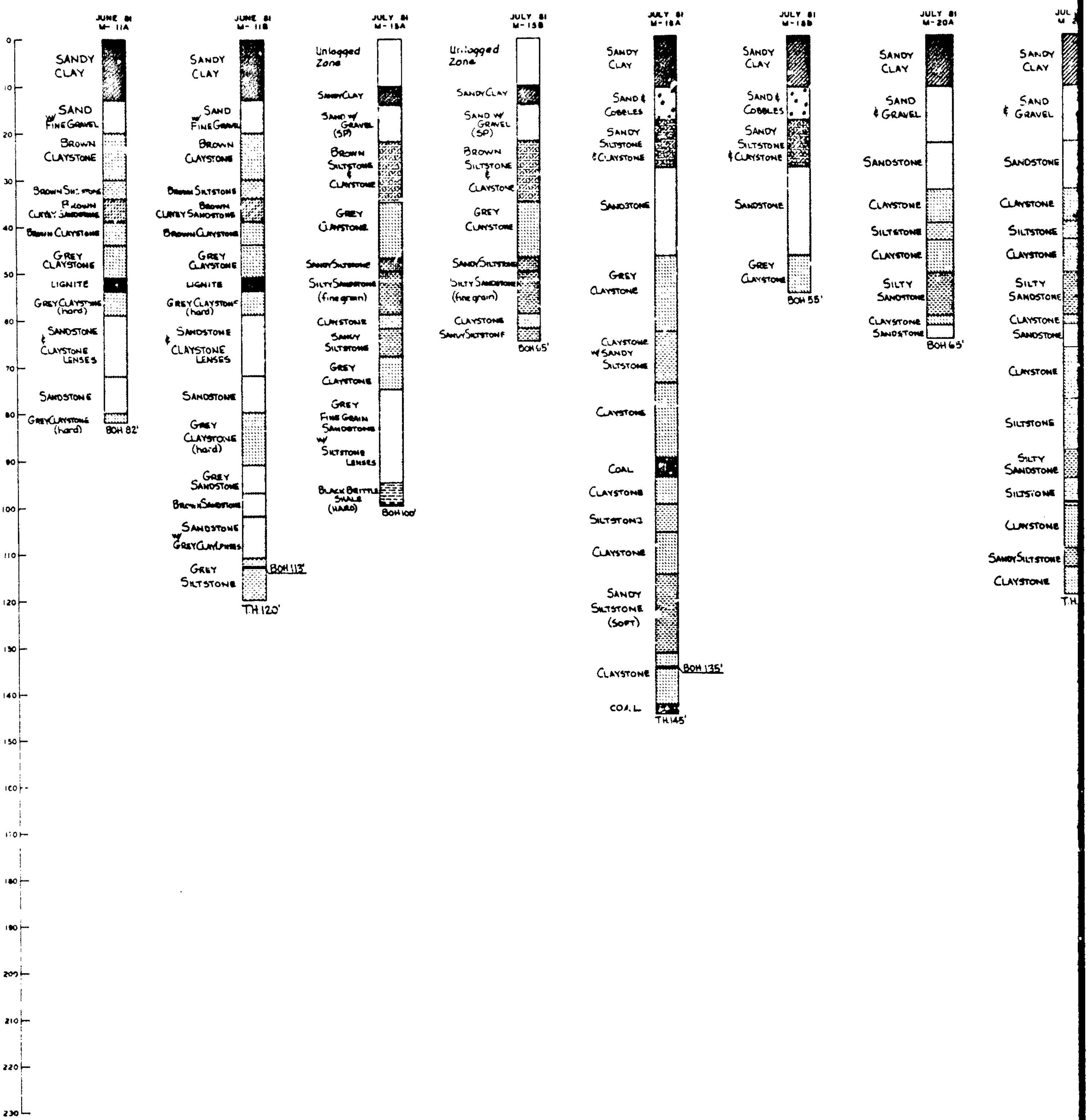
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

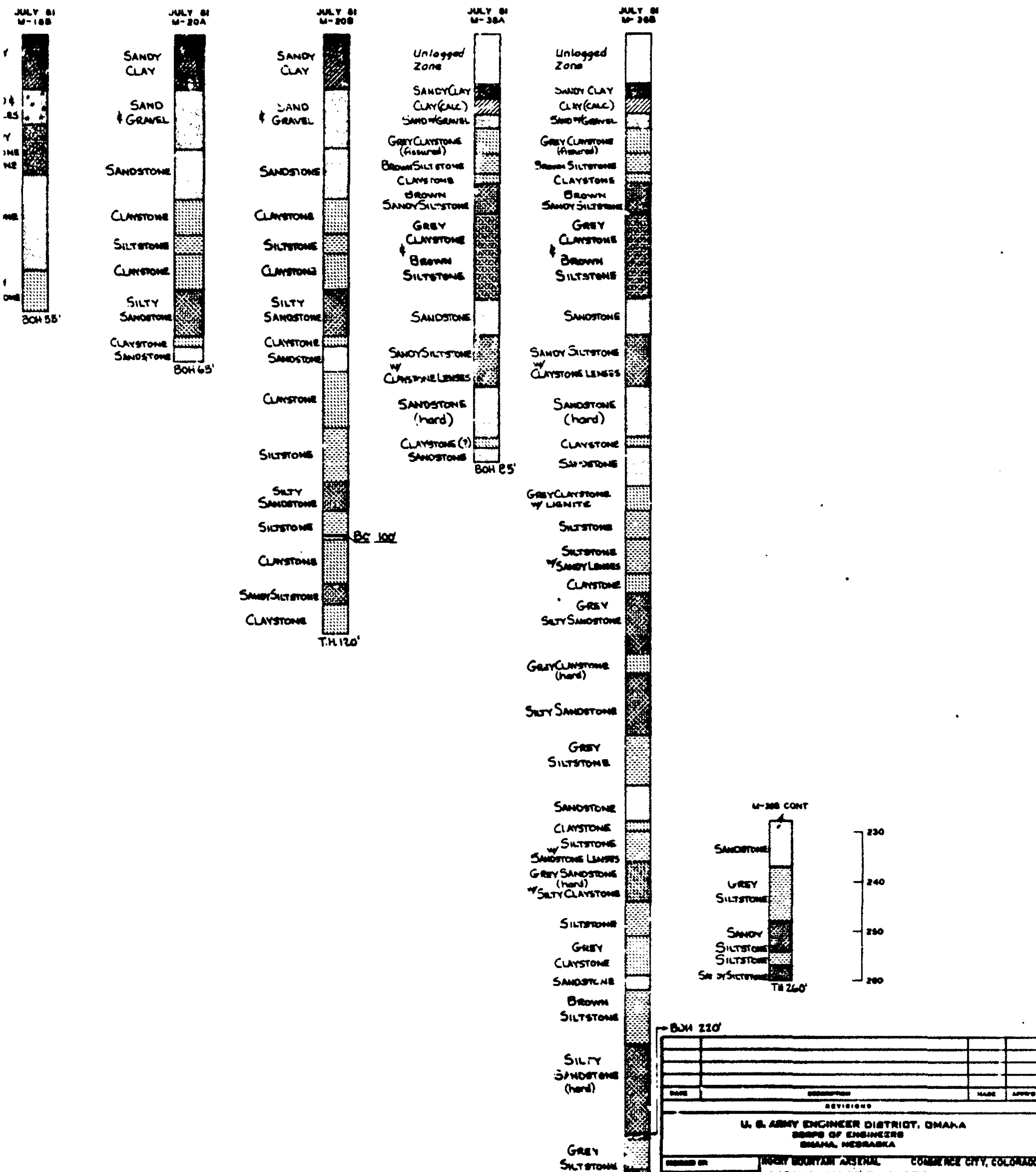
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
MONITOR WELL BORING LOGS
M-21 THROUGH M-39

SAFETY PAYS

71-07-16



JUNE 81 M-11A
JUNE 81 M-11B
JULY 81 M-15A
JULY 81 M-15B
JULY 81 M-18A
JULY 81 M-18B
JULY 81 M-20A
SANDY CLAY
SAND W/ FINE GRAVEL
BROWN CLAYSTONE
BROWN SILTSTONE
BROWN CLAYEY SANDSTONE
BROWN CLAYSTONE
GREY CLAYSTONE
LIGNITE
GREY CLAYSTONE (hard)
SANDSTONE & CLAYSTONE LENSES
SANDSTONE
BOH 82'
GREY SANDSTONE
BROWN SANDSTONE
SANDSTONE W/ GREY CLAY LENSES
BOH 113'
GREY SILTSTONE
T.H. 120'
Unlogged Zone
SAND W/ GRAVEL (SP)
BROWN SILTSTONE & CLAYSTONE
SANDY SILTSTONE
SILTY SANDSTONE (fine grain)
GREY FINE GRAIN SANDSTONE W/ SILTSTONE LENSES
BLACK BRITTLE SHALE (HARD)
BOH 100'
BOH 65'
SAND & COBBLES
SANDY SILTSTONE & CLAYSTONE
CLAYSTONE W/ SANDY SILTSTONE
COAL
SANDY SILTSTONE (SOFT)
BOH 135'
T.H. 145'
BOH 55'
SAND & GRAVEL
SILTY SANDSTONE
T.H.



THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPR'D

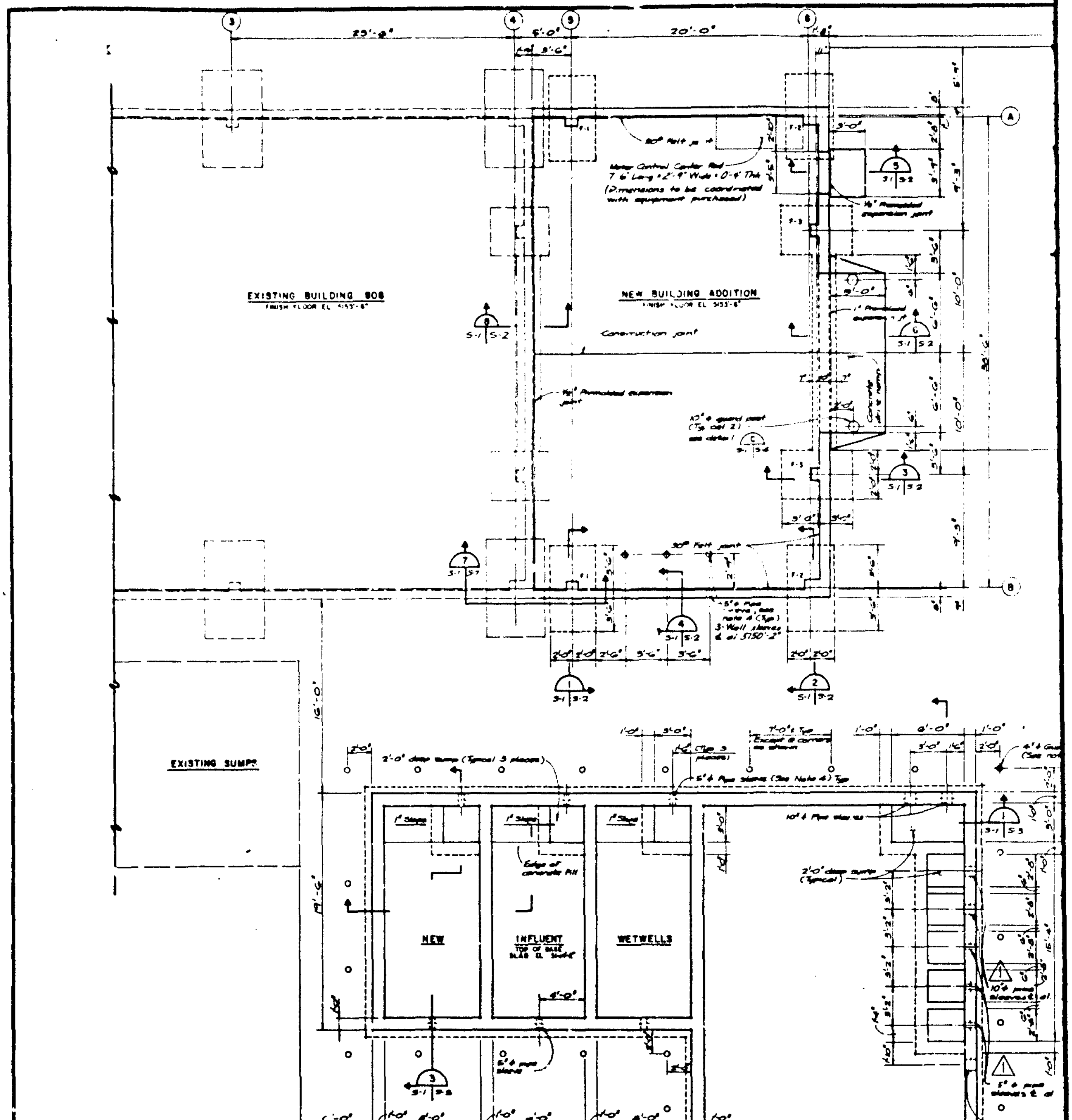
REVISIONS

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

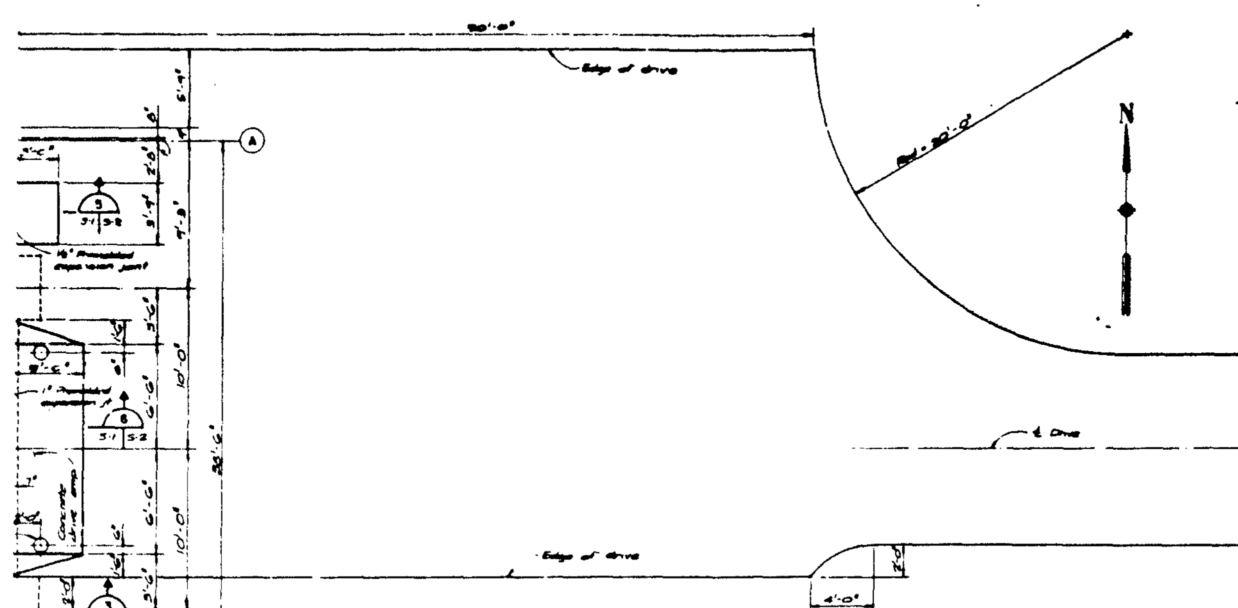
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
MONITOR WELL BORING LOGS
TWO WELL CLUSTERS

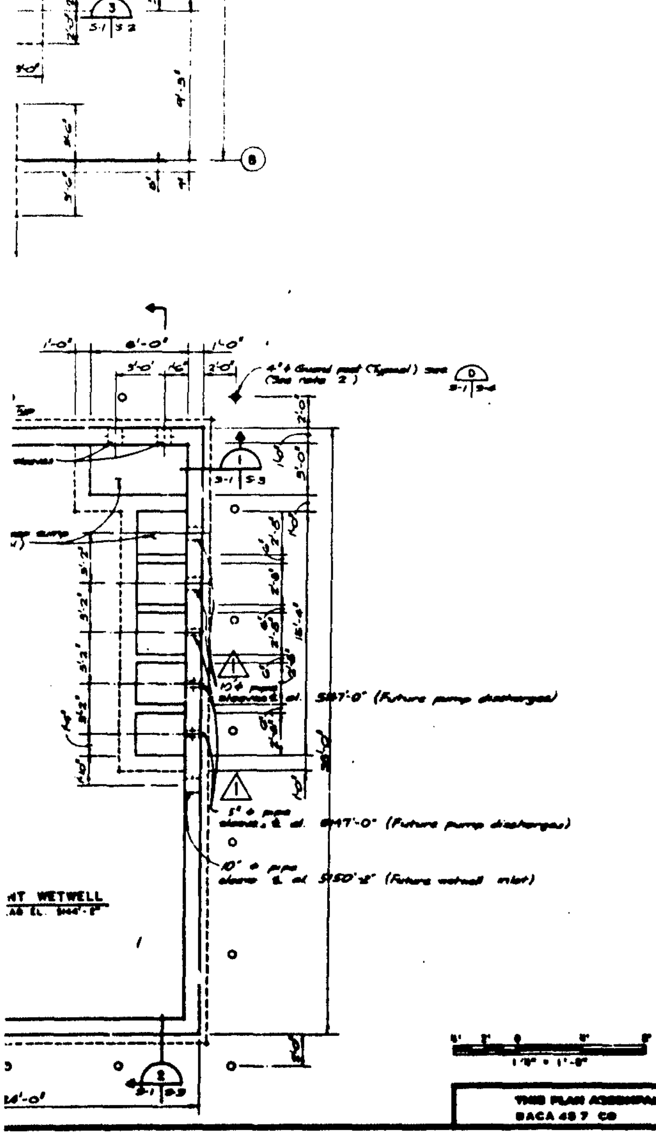
71-07-16



FOUNDATION PLAN

Notes
1. Contractor to remove existing 8'-0" x 5'-6" concrete slab at east personnel door prior to constructing new building addition.
2. Guard posts to be located so as not to interfere with sidewall piping.
3. Locations and sizes of slab and/or wall openings for organic removal process (activated carbon) discharge lines not shown. This information to be coordinated by contractor with RMA.
4. For wall and floor sleeve detail see





GENERAL STRUCTURAL NOTES

DESIGN DATA

1. DESIGN LOADS
   - A. ROOF LIVE LOAD = 30 PSF
   - B. OTHER LIVE LOADS AS FOLLOWS:
     1. FLOOR SLAB = 150 PSF
     2. WETWELL TOP SLAB = 100 PSF
   - C. WIND LOAD = 25 PSF
   - D. SEISMIC LOADS CONFORMING TO TM5-809-10 WITH THE FOLLOWING DATA:
     1. SEISMIC ZONE = 1
     2. Z = 0.25, C = 0.1, K = 1 33
   - E. LATERAL SOIL PRESSURE = ACTIVE SOIL PRESSURE + FULL HYDROSTATIC PRESSURE
     1. DRY SOIL UNIT WEIGHT = 120 PCF
     2. RANKINES ACTIVE PRESSURE FACTOR = 0 33
2. FOUNDATIONS
   - A. ALL SPREAD FOOTING TYPE FOUNDATIONS HAVE BEEN DESIGNED FOR A MAXIMUM SOIL BEARING PRESSURE OF 1400 PSF
   - B. FROST PENETRATION DEPTH = 42 INCHES.

MATERIALS

1. CONCRETE
   - A. CLASS AA, 4000 PSI AT 28 DAYS, FOR ALL PORTIONS OF STRUCTURES CONTAINING LIQUIDS.
   - B. CLASS A, 3000 PSI AT 28 DAYS, FOR ALL OTHER CONCRETE WORK NOT OTHERWISE NOTED
2. REINFORCEMENT
   - A. BARS, ASTM A615, A616, A617, GRADE 60 EXCEPT FOR TIES AND STIRRUPS WHICH SHALL BE ASTM A615 OR A617, GRADE 40
   - B. MESH REINFORCEMENT, ASTM A185
3. STRUCTURAL STEEL
   - A. PLATES AND SHAPES, ASTM A36.
4. ANCHOR BOLTS; ASTM A-307 UNLESS OTHERWISE NOTED

DETAILS

1. CONCRETE AND REINFORCEMENT DETAILS UNLESS SHOWN OTHERWISE SHALL CONFORM TO ACI 315 AND 318.
2. DIMENSIONS
   - A. DIMENSIONS INDICATED WITH AN ASTERISK (*) SHALL BE COORDINATED WITH EQUIPMENT FURNISHED.
3. WATERSTOPS SHALL BE 6" DUMBBELL POLYVINYLCHLORIDE AND SHALL BE PLACED WHERE INDICATED ON THE DRAWING.
4. SEE MECHANICAL AND ELECTRICAL DRAWINGS FOR SIZE AND LOCATION OF PIPE HANGERS, PIPE SUPPORTS, CONDUITS AND OTHER MECHANICAL AND ELECTRICAL ITEMS TO BE EMBEDDED IN CONCRETE.

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

DATE	DESCRIPTION	MADE	APPROVED
8-19-80	GENERAL REVISIONS		C.O.R.

REVISIONS

PREPARED BY BLACK & VEATCH, CONSULTING ENGINEERS, KANSAS CITY, MISSOURI

U.S. ARMY ENGINEER DISTRICT OMAHA, CORPS OF ENGINEERS, OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL — COMMERCE CITY, COLORADO

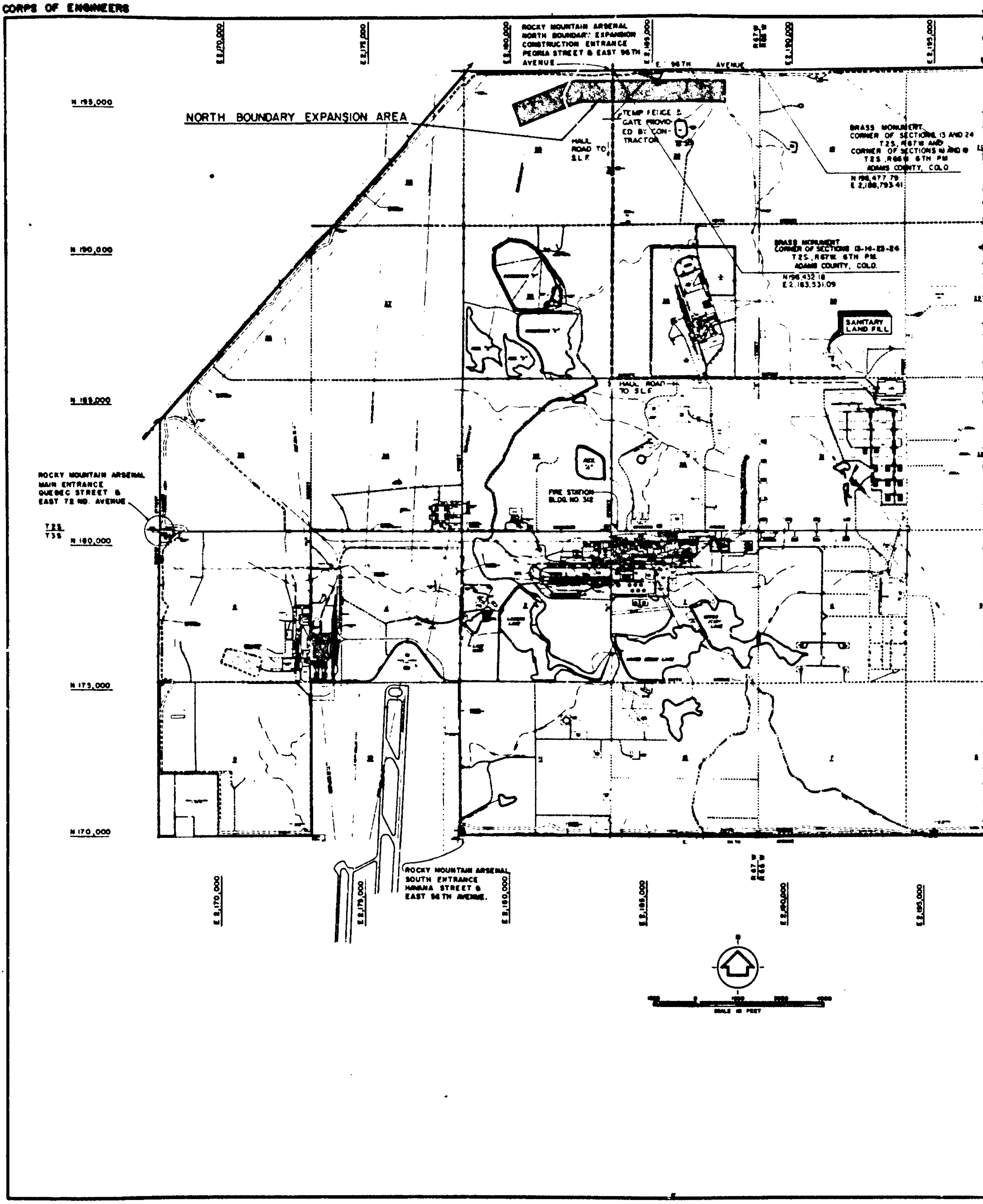
LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
FOUNDATION PLAN FOR BLDG. 808 ADDITION AND WETWELLS

JUNE 1980

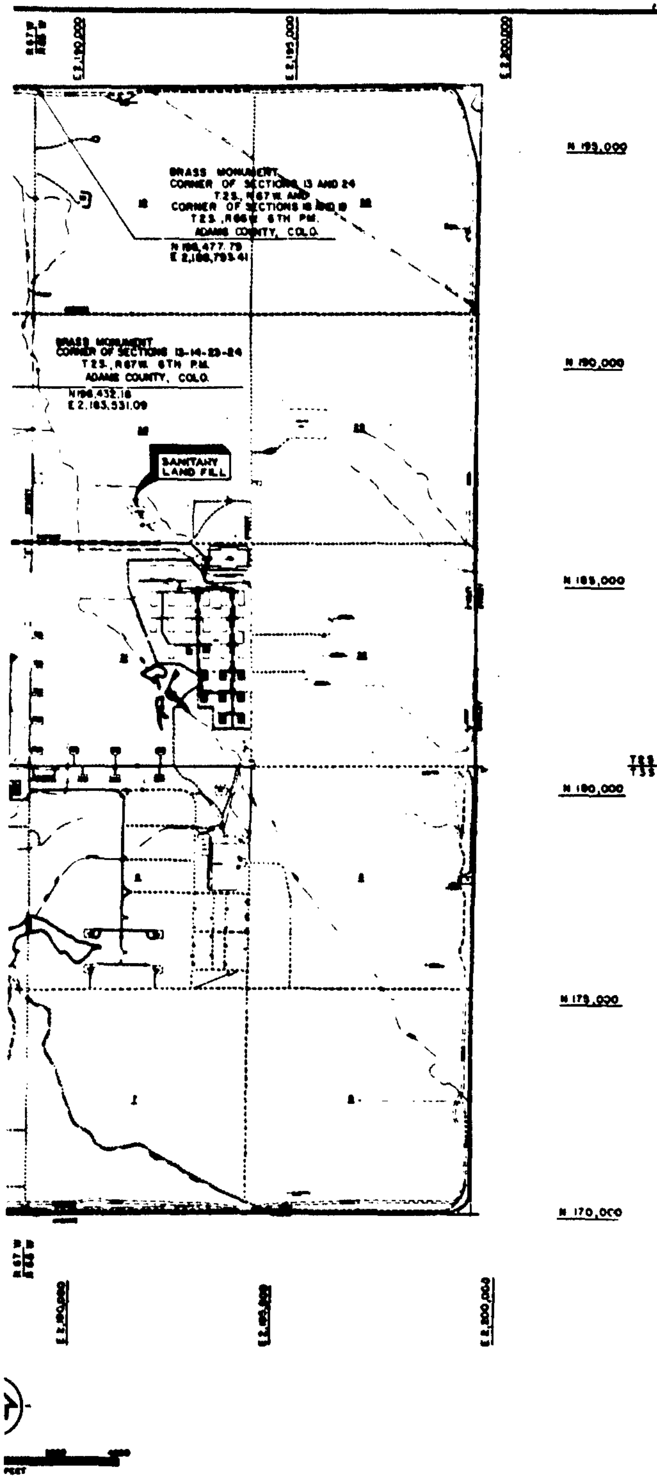
71-07-16

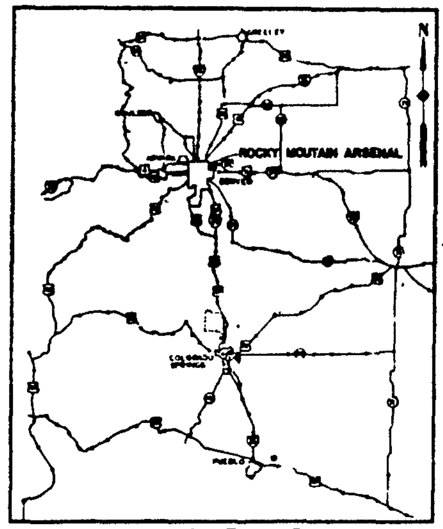
2

CORPS OF ENGINEERS



U. S. ARMY





VICINITY MAP

NO SCALE

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY BLACK & VEATCH

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

DAD

RWR

JEB

COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
LOCATION PLAN

JUNE 1968

71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO.
DACA45 MODIFICATION NO.

PLATE 88

SOIL CLASSIFICATIONS

SYMBOL	LETTER	DESCRIPTION
	GW	WELL GRADED GRAVELS OR GRAVEL-SAND MIXTURES. LITTLE OR NO FINES
	GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES. LITTLE OR NO FINES
	GM	SILTY GRAVELS. GRAVEL-SAND-SILT MIXTURES
	GC	CLAYEY GRAVELS. GRAVEL-SAND-CLAY MIXTURES
	SC-GC	DUAL CLASSIFICATION
	SW	WELL GRADED SANDS OR GRAVELLY SANDS. LITTLE OR NO FINES
	SP-GP	DUAL CLASSIFICATION
	SP	POORLY GRADED SANDS OR GRAVELLY SANDS. LITTLE OR NO FINES
	SM	SILTY SANDS. SAND-SILT MIXTURES
	SC	CLAYEY SANDS. SAND-CLAY MIXTURES
	SM-SC	DUAL CLASSIFICATION
	SM-SP	DUAL CLASSIFICATION
	ML	INORGANIC SILTS AND VERY FINE SANDS. ROCK FLOUR. SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY GRAVELLY CLAYS. SANDY CLAYS. SILTY CLAYS. LEAN CLAYS
	ML-CL	DUAL CLASSIFICATION
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAYS OR LOW PLASTICITY
	MH	INORGANIC SILTS. MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS. ELASTIC SILTS
	CH	INORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY. ORGANIC SILTS
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY. ORGANIC SILTS
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS

ROCK CLASSIFICATIONS

SYMBOL	DESCRIPTION
	SANDSTONE. SILTY OR CLAYEY SANDSTONE
	SILTY SANDSTONE/SANDY SILTSTONE
	CLAYEY SANDSTONE/SANDY CLAYSTONE
	SILTSTONE. SANDY OR CLAYEY SILTSTONE
	CLAYEY SILTSTONE/SILTY CLAYSTONE
	CLAYSTONE. SILTY OR SANDY CLAYSTONE
	COAL, LIGNITE
	SHALE

GEOPHYSICAL BORING LOGS (ELECTRICAL) SYMBOLS AND ABBREVIATIONS

(SEE SHEETS C-40 THRU C-60)

SYMBOL	DEFINITION
Ω	OHMS
γγ OR YY	GAMMA GAMMA RADIATION
N-N	NEUTRON RADIATION

ABBREVIATION	
CAL	CALIBRATION
CPS	CYCLE PER SECOND
DIV	DIVISION
FT	FEET
IN	INCH
K	THOUSAND
MIN	MINUTE
MV	MILLI-VOLT
N/A	NOT APPLICABLE
PQ	PQ WIRE LINE CORING
R	RESISTANCE
SP	SPONTANEOUS POTENTIAL
UNK	UNKNOWN

CLAY CONSISTENCY

CHARACTERISTIC	DESCRIPTION	BLOWS/FT
VERY SOFT	WITHOUT FORM	<2
SOFT	READILY DEFORMED BY FINGERS WITH LIGHT PRESSURE OR EASILY SQUEEZED THROUGH FINGERS	2-4
MEDIUM STIFF	EASILY DEFORMED BY FINGERS WITH MODERATE PRESSURE. BUT CANNOT BE SQUEEZED THROUGH FINGERS	4-8
STIFF	DEFORMED WITH DIFFICULTY BY FINGERS. A PENCIL JABBED INTO THE SAMPLE WILL PENETRATE AND TEND TO STICK	8-15
VERY STIFF	THIS IS NOT A TYPICAL COE (a) CLAY CONSISTENCY CHARACTERISTIC	15-30
HARD	CAN BE GOUGED BY FINGERNAIL. A PENCIL JABBED INTO THE SAMPLE WILL PENETRATE SLOWLY BUT DOES NOT TEND TO STICK	>30

COMPACTNESS (SILT AND SAND)

CHARACTERISTIC	BLOWS/FT.
LOOSE	<10
MEDIUM DENSE	10-30
DENSE	30-50
VERY DENSE	>50

ROCK-FRACTURES

CHARACTERISTIC	DESCRIPTION
CRUSHED	GENERALLY REFERS TO ROCK WHICH IS HIGHLY FRACTURED OR FRAGMENTAL BUT CONTAINS SOME CLAY MATERIAL INTERMIXED. IMPLICATION OF BEING MOVEMENT INDUCED.
FRAGMENTED	CORE IN PIECES (BUT NOT MECHANICALLY BROKEN). WHICH WERE TOO SMALL EVEN TO BE MEASURED AS CORE LENGTHS.
CLOSELY FRACTURED	FRACTURES SPACED GENERALLY LESS THAN 0.5 FOOT APART
MODERATELY FRACTURED	FRACTURES SPACED GENERALLY BETWEEN 0.5 FOOT AND 1.0 FOOT APART

ROCK-HARDNESS

CHARACTERISTIC	DESCRIPTION
SOFT	CAN BE SCRATCHED WITH FINGERNAIL.
FRIABLE	EASILY REDUCED TO CRUMB OR GRAIN WITH MODERATE FINGER PRESSURE. (THIS IS NOT A TYPICAL COE (a) ROCK HARDNESS CHARACTERISTIC.)
MODERATELY HARD	CAN BE SCRATCHED EASILY WITH A KNIFE. CANNOT BE SCRATCHED WITH A FINGERNAIL.
HARD	DIFFICULT TO SCRATCH WITH A KNIFE.
VERY HARD	CANNOT BE SCRATCHED WITH A KNIFE.

(a) CORPS OF ENGINEERS

	SITE	
—DW—	—DW—	DEWATER COLLECTION LINE
—RW—	—RW—	RECHARGE WATER LINE
	—DW(a)—	DEWATER MANIFOLD LINE "A"
	—DW(b)—	DEWATER MANIFOLD LINE "B"
	—DW(c)—	DEWATER MANIFOLD LINE "C"

SYMBOLS

	BLOWS/FT
	<2
T :H	2-4
IATE	4-8
A	8-15
I-	15-30
ATE	>30

SYMBOL	DEFINITION
MO./DAY/YR.	ESTIMATED GROUND WATER LEVEL MEASURED AT TIME OF DRILLING
MO./DAY/YR.	WATER LEVEL MEASURED FROM PIEZOMETER.
	BORINGS DRILLED AND LOGGED BY EARTH SCIENCES ASSOCIATES INC.
	BORINGS DRILLED AND LOGGED BY OTHERS
DH	DRILL HOLE
N	DENOTES NUMBER OF BLOWS/FOOT FROM STANDARD PENETRATION TEST
	CEMENTED MATERIALS
	EARTH
	BEDROCK
S_u	SHEAR STRENGTH, PSI, OBTAINED FROM UNCONFINED COMPRESSIVE STRENGTH TESTS

;AND)

	BLOWS/FT.
	<10
	10-30
	30-50
	>50

ABBREVIATIONS

BRN.	BROWN
B.O.H.	BOTTOM OF HOLE
B.O.W.	BASE OF WEATHERING
CLC.	CALCEROUS
CL. FRA	CLOSELY FRACTURED
DA.	DAY
DIA.	DIAMETER
D.H.	DRILLED HOLE
FT.	FEET
FRA.	FRACTURED
FRAG.	FRAGMENTED
MED.	MEDIUM
MOD.	MODERATELY
M. FRA.	MODERATELY FRACTURED
MO.	MONTH
SL.	SLIGHTLY
T.H.	TEST HOLE
T.O.B.	TOP OF BEDROCK
T.O.H.	TOP OF HOLE
UW.	UNWEATHERED
WB.	WELL BOTTOM
W/	WITH
YR.	YEAR

HLY
NS
ICATION

BROKEN).
ASURED

4 0 5

1.5

CIVIL LEGEND

EXISTING	NEW	
		BUILDINGS
		ROADS
		CURB & GUTTER
		WALKS
5180	5180	CONTOURS (FEET ABOVE MEAN SEA LEVEL)
77.2	77.2	SPOT GRADE ELEVATIONS
		DIRECTION OF DRAINAGE
		CULVERT
DW	DW	DEWATER WATER LINE
RW	RW	RECHARGE WATER LINE
DW	DW	DEWATER WELLS
RW	RW	RECHARGE WELLS
	DW	BEDROCK SANDS DEWATER WELLS
DW	DW	DEWATER WELL PUMP HOUSE
	BW	BEDROCK SANDS DEWATER WELL PUMP HOUSE
RW	RW	RECHARGE WELL PUMP HOUSE
		BARBED WIRE
		GATE
		UTILITY POLE
		CENTRAL ANGLE OF CURVE

MODERATE
ICAL COE (4)

CANNOT

THIS DRAWING HAS BEEN REDUCED TO THREE-EIGHTHS THE ORIGINAL SCALE.

SAFETY PAYS

REVISIONS

BLACK & VEATCH
CONSULTING ENGINEERS KANSAS CITY, MISSOURI

U. S. ARMY ENGINEER DISTRICT OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

RWR
LWP

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOTECHNICAL LEGEND

JUNE 1980

THIS PLAN ACCOMPANIES CONTRACT NO.
DACA 45-? CO

71-07-16

GEOTECHNICAL NOTES

1. THE DATA SHOWN ON SHEETS C-13 THROUGH C-25, GRAPHICALLY BY SYMBOL AND NOTE, ARE COMPILATIONS OF DATA FROM THE FIELD LOGS WHICH ARE THE ONLY RECORD OF THE ACTUAL GEOLOGIC FEATURES OBSERVED FROM A DETAILED EXAMINATION OF THE CORE OBTAINED DURING EXPLORATORY DRILLING. THIS PRESENTATION OF DATA FROM THE FIELD LOG IS PROVIDED TO ASSIST THE CONTRACTOR IN HIS EXAMINATION OF THE CORE AT THE SITE ( ) AS A GUIDE IN THE STUDY OF THE FIELD LOGS.

2. THE LOGS SHOWN ON SHEETS C-40 THROUGH C-69 AND THE FIELD LOGS ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS FOR THE EXPLORATORY BORINGS AT THEIR RESPECTIVE LOCATIONS AS SHOWN ON THE DRAWINGS, AND FOR THEIR RESPECTIVE REACHES. LOCAL VARIATIONS CHARACTERISTIC OF SUBSURFACE MATERIALS OF THIS REGION ARE ANTICIPATED.

3. LETTER SYMBOLS SUCH AS GC, SC, SP, SM, CL, ETC. ARE IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM OF THE DEPARTMENT OF DEFENSE (MIL-STD-619B).

4. CLASSIFICATION OF BEDROCK IN ACCORDANCE WITH SYMBOLS AND CATEGORIES SHOWN IS A VISUAL CLASSIFICATION. THE ROCKS BELONG TO THE DENVER FORMATION OF LATE CRETACEOUS AND EARLY TERTIARY (PALEOCENE) AGE. FOR THE MOST PART, THE DENVER FORMATION IS COMPOSED OF SANDSTONES, SILTSTONES, AND CLAYSTONES. STRUCTURALLY THE MATERIAL IS INTERBEDDED IN BEDS VARYING FROM LESS THAN 1 FOOT TO GREATER THAN 10 FEET IN THICKNESS. LATERAL CONTINUITY IS UNCOMMON WITH MOST UNITS LENSING OUT OR INTERFINGERING WITH OTHER UNITS. THE DEGREE OF WEATHERING, FRESHNESS, AND FRACTURING OF THE ROCK WAS DETERMINED BY THE PHYSICAL APPEARANCE AND CONDITION OF THE CORE. DEFINITIONS OF DESCRIPTIONS OF ROCK FRACTURES AND HARDNESS AND ROCK CLASSIFICATIONS ARE SHOWN ON GEOTECHNICAL LEGEND SHEET 4.

5. CONTINUOUS PQ CORE SAMPLES OF THE DENVER FORMATION MATERIALS (30 HOLES) ARE AVAILABLE FOR INSPECTION AT ROCKY MOUNTAIN ARSENAL. BIDDERS SHOULD EXAMINE THE CORE SAMPLES TO SATISFY THEMSELVES AS TO THE PHYSICAL PROPERTIES OF THE ROCK.

6. DRILLING METHODS ARE DENOTED AS FOLLOWS:
   - A.B — AUGER BORING
   - A.B & C — AUGER BORING AND ROTARY CORING
   - RW — ROTARY WASH CORING
   - MNS — METHOD NOT STATED

7. DRILL HOLES WERE ACCOMPLISHED BY:
   - A. STANDARD PENETRATION TEST PROCEDURE USING A 1-3/8" ID X 2'-6" LONG SPLIT SPOON. SAMPLE SPOONS WERE ADVANCED BY A 140 POUND HAMMER FALLING 30 INCHES. SOME HOLES WERE SAMPLED CONTINUOUSLY AND OTHERS WERE POWER AUGERED BETWEEN SAMPLES.
   - B. CORING WAS ACCOMPLISHED USING PQ-3 WIRELINE EQUIPMENT. THE LENGTH OF THE INNER SAMPLE BARREL WAS 10.0' AND THE INSIDE DIAMETER WAS 3.24". FIVE TO TEN FOOT LENGTHS OF CORE WERE CUT UTILIZING DIAMOND OR CARBIDE BITS.

8. CORE LOGS ARE SHOWN GRAPHICALLY (AND SOMETIMES BY NOTE IN THE REMARKS COLUMN) ON ESA(*) DRILLING LOGS. (RIGHT HAND SIDE OF SAMPLE COLUMN.)

9. BORINGS DENOTED WITH AN ASTERISK "*" ARE SHOWN ONLY IN PLAN. LOGS FOR THESE PARTICULAR BORINGS ARE AVAILABLE FROM THE OMAHA DISTRICT OFFICE, CORPS OF ENGINEERS.

10. GROUND WATER LEVELS ARE NOT AVAILABLE FOR ALL BOREHOLES. ABSENCE OF GROUND WATER DATA ON A BORING LOG DOES NOT NECESSARILY MEAN THAT GROUND WATER WILL NOT BE ENCOUNTERED AT THAT LOCATION WITHIN THE VERTICAL REACH OF THE BORING. GROUND WATER LEVELS INDICATED ON BORING LOGS REFLECT THE LEVEL AT THE TIME MEASURED. GROUND WATER LEVELS MAY VARY WITH TIME.

11. RELATIVE DENSITY OF SAND STRATA AND CONSISTENCY OF SILT OR CLAY WERE ESTIMATED BY VISUAL INSPECTION OF SOIL SAMPLES AT TIME OF DRILLING. DEFINITIONS OR DESCRIPTIONS OF CLAY CONSISTENCY AND COMPACTNESS OF SILT AND SAND ARE SHOWN ON GEOTECHNICAL SHEET 4.

12. MOISTURE CONTENT DESCRIPTIONS WERE ESTIMATED BY VISUAL IN[SPEC-]TION OF SAMPLES AT THE TIME OF DRILLING

13. MORE DETAILED INFORMATION ON DRILLING PROGRESS, CORE LOSS WATER DATA, FRACTURES AND OTHER DATA ARE SHOWN ON THE LOGS. COPIES OF THE FIELD LOGS ARE AVAILABLE FOR INSPEC IN THE OFFICE OF THE U S ARMY ENGINEER DISTRICT, OMAHA, AND IN THE OFFICE OF THE DENVER/CHEYENNE RESIDENT ENGINE OFFICE, DENVER, CO.

14. LINES BETWEEN BORINGS DESIGNATED AS TOP OF BEDROCK ARE E MATES ONLY.

15. ELEVATIONS DENOTED (BY TOPO) WERE DETERMINED BY INTERPOL FROM THE CONTOUR MAP.

16. SHEAR STRENGTHS (S_u) WERE OBTAINED FROM UNCONFINED COMP STRENGTH TESTS ON CORE SAMPLES FROM THE DENVER FORMATIO

ERA	SYSTEM OR PERIOD	SERIES	GEOLOGIC UNIT	
Cenozoic	Quaternary	Recent and Pleistocene	Quaternary surficial deposits	Stream c… flood-plain … terrace dep… eolian sand…
	Tertiary	Oligocene	Castle Rock Conglomerate	
			Tertiary intrusive and extrusive rocks	
Cenozoic and Mesozoic	Tertiary and Cretaceous	Paleocene ---?--- Upper Cretaceous	Dawson Group	Dawson Ar… Denver For… Arapahoe F…
Mesozoic	Cretaceous		Laramie Formation	Upper part
				B sandstone
				A sandstone
			Fox Hills Sandstone	Milliken Sa…
				lower part
			Pierre Formation	
			Niobrara Formation	Smoky Hill …
				Fort Hayes
				Limestone
			Benton Formation	Carlile Shal…
				Greenhorn L…
				Graneros Sh…
		Lower Cretaceous	Dakota Group	South Platte
				Formation
				Lytle Format…
	Jurassic	Upper Jurassic	Morrison Formation	
			Ralston Creek Formation	
Paleozoic	Triassic ? and Permian		Lykins Formation	Strain Shale
				Glennon Lim…
				Bergen Shale
				Falcon Limes…
				Harriman Sh…
	Permian		Lyons Sandstone	
	Pennsylvanian		Fountain Formation	
			Glen Eyrie Formation	
	Mississippian		Madison Limestone	
			Williams Canyon Limestone	
	Ordovician and Cambrian		Manitou Dolomite	
	Cambrian		Sawatch Sandstone	
Precambrian			crystalline rocks	

GENERALIZED STRATIGRAPHIC SECTION
OF THE DENVER BASIN, COLORADO
(ROMERO, 1976)

(*) EARTH SCIENCES ASSOCIATES OF PALO ALTO, CALIFORNIA

ENT DESCRIPTIONS WERE ESTIMATED BY VISUAL INSPEC-
ES AT THE TIME OF DRILLING.

INFORMATION ON DRILLING PROGRESS. CORE LOSS.
RACTURES AND OTHER DATA ARE SHOWN ON THE FIELD
OF THE FIELD LOGS ARE AVAILABLE FOR INSPECTION
OF THE U.S. ARMY ENGINEER DISTRICT. OMAHA. NE.
FICE OF THE DENVER/CHEYENNE RESIDENT ENGINEER
R. CO.

BORINGS DESIGNATED AS TOP OF BEDROCK ARE ESTI-

NOTED (BY TOPO) WERE DETERMINED BY INTERPOLATION
OUR MAP.

HS (S_u) WERE OBTAINED FROM UNCONFINED COMPRESSIVE
S ON CORE SAMPLES FROM THE DENVER FORMATION.

OR OD	SERIES	GEOLOGIC UNIT	
ry	Recent and Pleistocene	Quaternary surficial deposits	Stream channel, flood-plain and terrace deposits; eolian sand, etc.
	Oligocene	Castle Rock Conglomerate	
		Tertiary intrusive and extrusive rocks	
us	Paleocene ——?—— Upper Cretaceous	Dawson Group	Dawson Arkose Denver Formation Arapahoe Formation
		Laramie Formation	Upper part B sandstone A sandstone
		Fox Hills Sandstone	Milliken Sandstone lower part
		Pierre Formation	
us		Niobrara Formation	Smoky Hill Shale Fort Hayes Limestone
		Benton Formation	Carlile Shale Greenhorn Limestone Graneros Shale
	Lower Cretaceous	Dakota Group	South Platte Formation Lytle Formation
	Upper Jurassic	Morrison Formation	
		Ralston Creek Formation	
		Lykins Formation	Strain Shale Glennon Limestone Bergen Shale Falcon Limestone Harriman Shale
		Lyons Sandstone	
		Fountain Formation	
		Glen Eyrie Formation	
		Madison Limestone	
		Williams Canyon Limestone	
		Manitou Dolomite	
		Sawatch Sandstone	
		crystalline rocks	

ALIZED STRATIGRAPHIC SECTION
HE DENVER BASIN, COLORADO
(ROMERO, 1976)

THIS DRAWING HAS BEEN REDUCED TO
THREE-EIGHTHS THE ORIGINAL SCALE.

REVISIONS

PREPARED BY
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ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
GEOTECHNICAL NOTES

CJS
JER

JUNE 1980

NO SCALE

71-07-16

THIS PLAN ACCOMPANIES CONTRACT NO.
DACA 45-7 CO MODIFICATION NO.

END

DATE
FILMED

10-85